Modern Warfare

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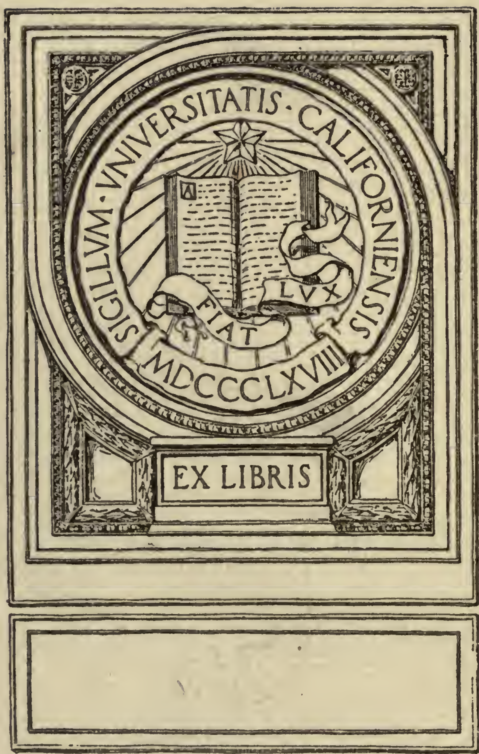
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By

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INTRODUCTION

ALONG in the Middle Ages, three revolutionary mechanisms or inventions were introduced in Europe. One was the mariner's compass, which opened up new geographical worlds. The second was the printing press, which prepared the way for the diffusion of knowledge. The third was gunpowder, which transformed the destructive but ever-prevalent industry of warfare.

A mediæval optimist might have prophesied that the compass would open up new fields to the colonist and relieve the economic pressure that is the underlying cause of wars; and that the printing press would so diffuse culture that men would become too intelligent to waste time, energy, and money in wholesale mutual murder—hence that the invention of gunpowder must prove a matter of slight significance.

But such an optimist would indeed have been a false prophet. For, as the event was to prove, the opening up of new geographical territories implied new regions to be conquered and fought for; improved economic conditions enabled populations to double and quadruple, that there might be more human material for slaughter; and the spread of knowledge insured only that destructive mechanisms should be devised more cunningly

to carry forward the mission of carnage on land and sea—ultimately even in the air above and in the water under the earth.

And in determining the character of these mechanisms of offensive and defensive warfare, the new invention, gunpowder, was to be the chief factor for several centuries, until gunpowder itself was superseded, as the chief agent of destruction, by other explosives that were, so to speak, its lineal descendants.

So the history of modern warfare naturally begins with the story of the introduction of this all-important agent of destruction.

Hitherto, arrow and lance and sword had been matched from time immemorial against portable shield and vestment armor. Hand-swung battering ram and catapult-hurled stones were matched against relatively feeble fortresses that none the less proved impregnable. Battles were hand-to-hand conflicts, where individual prowess had full scope, and where the warrior with physical strength to bear armor of extra weight and to wield a sword or lance heavier than the average became the hero of his allies and the terror of the enemy.

But gunpowder changed all that. The simple mixture of charcoal and sulphur and saltpeter (nitrate of potash), with its curious capacity to change suddenly into a gas if ignited, proved itself the most wonderful of social levelers. As a democratizing influence the explosive far surpassed the printing press. At a single puff, it

unhorsed the proud and arrogant knight, made his armor worse than useless; his death-dealing sword and lance became ineffectual incumbrances. So the picturesque paraphernalia of the knight-errant that had rendered mediæval warfare at once spectacular and relatively harmless was relegated to the junk heap, whither longbow and arquebus presently followed it; the despised foot soldier supplanted the cavalryman as the really effective agent in the fighting mechanism; and presently an artillery service was developed of which antecedently there had been only the faintest adumbration in the cumbrous and ineffective battering ram and catapult.

Of the entire equipment of the mediæval soldier, only the sword remained virtually unmodified, and this rather as an ornament than as a weapon of service; although the pike might be said to persist in the modified form of bayonet and lance as accessory to the work of the firearms at close quarters.

Even to this day, to be sure—since no social change is altogether metamorphic—there are troops of cavalry that retain somewhat the appearance and a reminiscence of the equipment of the armored, lance-bearing horsemen of knightly tradition; but these constitute only a fringe on the great military fabric, the body of which is made up of bearers of the death-dealing musket and rifle. Human ingenuity has gone far in the endeavor to find more and more effective weapons for the killing of men, until the range of projec-

tiles is measured in miles; the power of explosives is appalling, the cost of armaments prodigious beyond the wildest dreams of ancient spendthrift governments; and the toll of human lives ghastly beyond the wildest nightmares of an Alexander or a Cæsar or a Jenghiz Khan.

It is difficult to contemplate the subject without adverting to its moral aspects; but these speak for themselves, and do not fall within the scope of the present inquiry. In the ensuing chapters we are not concerned with warfare in its sociological or its economic aspects; but solely with the art of war on its mechanical side. It is the story of human ingenuity in its application to the development of the mechanisms of warfare—offensive and defensive—in modern times that will claim our attention. And assuredly it is a story not lacking in human interest.

MODERN WARFARE

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I

THE INTRODUCTION OF FIREARMS

IT is rather curious that the invention of gunpowder is wrapped in obscurity. Even the time of its introduction into warfare cannot be definitely established.

As an explosive, some mixture resembling gunpowder had been known for many centuries before its employment as a propelling agent. It has been suggested even that the ancients were familiar, not only with the explosive qualities of such a substance, but also with its use for projecting missiles.

The obscurity of the writings which are the foundations of such beliefs, however, and the different interpretations that may be given them, make any positive assertion that gunpowder, as a propelling agent, was known before the late Middle Ages untenable. Yet some of the classical references are not without interest.

For example, Virgil tells of Salmoneus, king of Elis, who was slain by Jupiter for his audacity in attempting to imitate thunder and lightning. By some this is thought to show that Salmoneus had discovered some explosive compound like

gunpowder, and was killed by an accidental explosion, his death being interpreted as a punishment of the god of thunder.

Dion Cassius in his *History of Rome* tells of engines used by Caligula which imitated thunder and lightning and hurled stones. Alexander the Great is thought by certain authors to have encountered firearms in his Indian campaign; and Archimedes is credited with having employed something resembling gunpowder among the other ingenious methods invented, or adapted, by him in the defense of Syracuse.

But all these alleged sources are lacking in authenticity. There is a great confusion in the interpretations of the ancient and mediæval literature on the subject, and it is easily supposable that many of the references interpreted as meaning explosives, or as propelling agents, really refer to substances like Greek fire, a description of which might be easily construed as referring to gunpowder.

The Chinese were long credited with having first invented gunpowder, and it is probable that some explosive mixture was known to them for many centuries before it was known in Europe. They did not utilize this knowledge in producing engines for propulsion, however, and their knowledge of an explosive, if they possessed such knowledge, plays no part in the history of firearms.

It is probable that gunpowder was used in war in the form of rockets or shells some time before

it was used as a propelling agent. The Arabs are supposed to have used it in this manner, and a document still in existence, written in 1250, describes such weapons. Ferarius, a Spanish monk and a contemporary of Roger Bacon, wrote a treatise on Greek fire, rockets, and "thunder" which is still preserved in the Bodleian Library at Oxford; and it was possibly from this source that Roger Bacon became acquainted with a compound which he described, and which he has sometimes been credited with inventing. It seems more likely, however, that his knowledge was obtained from the Arabs.

But the mere invention of gunpowder, as such, is of little importance compared with its application as a propellant. This use seems to have been first made either by the Moors or Saracens. Ismail, king of Granada, is believed to have used cannon at the siege of Baza in 1325; but probably the first reliable contemporary account of this use is a document still in existence, written in 1326. This document, although not describing the actual use of firearms, refers to their manufacture specifically in a manner quite unequivocal.

It is certain, therefore, that by the time of the battle of Crécy, in 1346, firearms were known, and there is some ground for believing that the English used cannon at that battle. It is equally certain, however, that any part played by cannon in determining the issue at Crécy was a minor one. But by the end of the fourteenth century cannon had become recognized weapons of war-

fare, and the development of small arms in the form of hand cannon is known to have kept pace with the development of the heavier weapons.

THE PRIMITIVE CANNON

It is an interesting fact that most of the early cannon, and possibly all of them, were breech-loaders; yet these were quickly replaced by muzzle-loading cannon and the system of breech-loading was not reintroduced to any extent until after the middle of the nineteenth century. The breech mechanism of the early cannon was so clumsy and unsatisfactory that once the muzzle-loader came into use it held its place, practically without alteration, for over three centuries.

The first cannon were not, as a rule, made of a single piece of metal, cast or bored to the proper shape, but of strips of metal fastened together by hoops of iron. Sometimes other substances, such as leather, were tried, and such cannon, made with metal tubes wound with leather, were used successfully by Gustavus Adolphus, as we shall see later. But such experiments soon proved unsatisfactory, and iron cannon came gradually into general use.

The mountings of the early cannon were crude affairs, and mounting pieces on wheels or gun carriages was not attempted until many years after the introduction of ordnance. The earliest cannon were carried about in carts, or on racks carried by the foot soldiers. When in use they

were placed upon the ground, the required elevation being obtained by blocks placed under the muzzle.

The impossibility of aiming such pieces made them of little account in the open field, but against fortifications their efficiency was demonstrated from the very beginning.

The besieging artillerymen, far beyond the range of the arrows from the ramparts, or protected by a sloping roof of planks, could determine the necessary elevation with a few discharges, and could then batter to pieces the walls of the fortress which afforded so large a target that the projectile would seldom miss it once the range had been found.

This method must have suggested, almost from the first, the use of the mortar for throwing missiles at high angles, and crude mortars came into use as early as the middle of the sixteenth century. It was some time, however, before the explosion of the powder was utilized to light the fuse of the shell. Indeed, this method of firing the shell did not come into vogue until late in the seventeenth century. The earlier method was for the artillerymen to use two firebrands, lighting the fuse of the shell with one hand and touching off the piece with the other.

IMPROVING THE CANNON

By the close of the fourteenth century *bombardes* were in existence which threw balls or

stones weighing two hundred pounds; and by the beginning of the fifteenth century many different types of cannon were in use.

Some of these were made of a number of comparatively small barrels, fastened together and mounted on rude carriages. These *ribaudequins,* as they were called, were the prototypes of the modern *mitrailleuse,* many barreled cannon. Some of these were made with as many as thirty-three separate barrels, with which a rapidity of fire was possible that was most disastrous to an enemy at close range. But the length of time required for reloading after each discharge more than offset the advantages of such weapons.

India did her full share in the development of early cannon, and there is reason to believe that as early as the beginning of the sixteenth century the Indians used breech-loading cannon of enormous size.

One of these immense guns was found in the bed of the Bagretti River, at Moorshedabad, in Bengal, in 1850.

" The bore of this colossal bombard is eighteen and one-half inches in diameter," says Chesney, " and its length twelve feet, two inches, independently of the movable chamber which is four feet two inches. The latter, which is of the same construction as the rest of the piece, fits into the frame when loaded, and seems to have been secured by firmly lashing a set of rings on each portion to one another, no doubt with the additional support of a block of wood, to prevent the

breech from separating by the force of the explosion, like the pieces recovered from the 'Mary Rose'; the cylinder as well as the breech of this enormous piece is formed of massive longitudinal bars of wrought iron, encircled by eleven powerful rings, encircling it at eleven inches apart. The bore is, however, uneven, being of very rude workmanship. But it should be borne in mind that such pieces were intended for stone shot, to be fired with small charges of powder, which, imperfect as is their construction, they would doubtless have borne."

The early Arabian authors state that cannon were first used by them in the form of cylinders bored into rocks. These, of course, could not be used in field operations; but in sieges, where a favorable rocky hillside faced the walls within reasonable distance—probably out of range of arrows and bolts, but still within gunshot range—such cylinders could be bored and used as cannon or mortars with telling effect.

A "cannon" of this kind was constructed in 1771 in the rock of Gibraltar, the object of its construction being to ascertain what effect could be produced by such a weapon. The excavation for this primitive mortar may still be seen in the rock. The bore is thirty-six inches in diameter, carefully polished like the muzzle of a mortar, and the depth of the excavation is four feet. Of course no vent or touch hole could be used, the charge being exploded by a fuse, or through a hollow tube placed in the opening.

When the "cannon" was discharged after being loaded with loose stones of various sizes, amounting to fifteen hundred pounds in weight, it propelled this load a distance of five hundred yards, scattering the stones over the surface of the water.

Portable guns were slow in coming into general use, the clumsiness of construction and weight of early ordnance restricting the use of artillery for a long time to siege operations and naval equipments. Charles VIII of France (1483-1493) is reputed to have first made serviceable the cannon for field as well as siege operations, by mounting it on wheels which served for transports as well as carriages from which the piece was fired. Before this, even mounted cannon were dismounted and made stationary for firing, the gun carriage only serving as a means of transport. Charles also restricted his cannon to certain calibers, ranging from pieces mounted on four wheels and drawn by thirty horses to light pieces that could be moved about almost as quickly as cavalry; but even these lighter pieces were clumsy enough and of little service.

Gustavus Adolphus must be credited with constructing the first practical portable cannon, and his victory near Leipzig in 1631 has been ascribed partly, at least, to the use of his light and mobile artillery. These cannon were remarkable structures, as the following description shows:

"His cannon consisted of a thin cylinder of beaten copper screwed into a brass breech, whose

chamber was strengthened by four bands of iron. The tube itself was covered with four layers of mastic, over which cords were rolled firmly round its whole length; these were equalized by a layer of plaster; and a coating of leather, boiled and varnished, completed the piece. The carriage and the piece were so light that two men were sufficient to draw and serve this kind of gun, which, as may be imagined, could only bear a small charge.''

At the battle of Leipzig against Tilly this light artillery turned defeat into victory, the early part of the engagement being favorable to Tilly, owing to his heavy artillery.

'' The action began with a cannonade,'' says Schiller, '' which lasted two hours, and which, owing to the superior caliber of the guns of the Imperialists, was favorable to Tilly; but his descent at the head of his center, to take advantage of this circumstance, was opposed and repulsed by the fire of thirty pieces of artillery in the center of the Swedish line. Tilly then united with his right and fell on the Saxons with such impetuosity that they took flight on the first shock.

'' The king, nothing daunted, assembled a mass of artillery to resist Peppenheim's attack on his right wing, and by the rapid fire of his light leather guns, completely defeated him, notwithstanding his vigorous and often repeated attacks. He then, at the head of the greater part of his army, took possession of the heights previously

occupied by the Imperialists, and captured and turned their guns against themselves, thus obtaining a brilliant victory which opened all Germany to the conqueror.''

But cannon of this construction were short-lived, and many of Gustavus' leather cannon did not last through the campaign. They had demonstrated the advantages of light, mobile artillery, however, and the beginning of the era of light field artillery dates from this period.

EUROPEAN ARMIES IN THE TRANSITION PERIOD

Fully to understand the progress of firearms in changing methods of warfare, something should be known about the condition of the armies of the most enlightened nations at the transition period when firearms were gradually replacing the other weapons but had not as yet entirely supplanted them. The study of the armies of the Thirty Years' War shows the condition of armies and arms during this transition period, and is of particular importance, as it was during this war, particularly under Gustavus Adolphus, that many improvements were made, not only in field artillery just referred to, but in small arms and in the methods of using them.

The armies of the Thirty Years' War bore little resemblance to the armies of recent times. The soldier went to the war taking with him his wife and children.

This was quite as true of the superior officers,

staff officers, and knights, as it was of the humblest private soldiers in the ranks.

But besides these incompetents, there was always a train of camp followers,—women who followed the camp, beggars, and criminals, whose number was often greater than the number of fighting soldiers.

When Gustavus took command of the army he attempted to do away with the worst of these evils, but he found this an impossible task. The armies numbered perhaps forty thousand soldiers, who had with them enough women, children, and camp followers to swell the number to something like one hundred thousand persons. Most of these had no homes at all, or their homes were in distant countries. To dismiss the camp followers from the army, taking with him nothing but the fighting men, was obviously out of the question. The soldiers would have rebelled at once and refused to follow their leader. To leave the sixty thousand camp followers behind to starve or to pillage the country would have been to produce a state of affairs fully as bad, if not indeed worse than, the existing condition.

The most that Gustavus could hope to do, therefore, was to improve the condition rather than revolutionize it.

One of his first steps was to establish field schools for the instruction of the children in the camp. Many of these schools were established and governed with military discipline, and all children of certain ages were obliged to attend

and receive instruction. Freytag tells the story of one occasion when a cannon ball from the artillery of the enemy fell among the children who were busy with their lessons, killing and wounding several.

Yet so accustomed were these children to such incidents that the survivors " went on doing their arithmetic."

The solution of the problem of caring for the little school children, however, was an easy one as compared with the question of controlling the women and some of the other camp followers, perhaps the worst among these being a class of lawless boys too old to attend the schools and too young as yet to carry arms. These boys were not the children of the soldiers, but were homeless waifs who followed the army, acting as pages or servants to the soldiers. They were the offscourings of the earth, and were a perennial source of trouble. Severe discipline was often tried with them, and they were frequently punished cruelly for their misdeeds, but this punishment had little or no effect in restraining them.

The outrages committed by these boys, camp women, and baggage servants helped to make the passage of the army more terrible in its effects than the battle itself. The following passage, taken from a contemporary writer, gives some conception of the outrages committed by these followers of the army:

" When the women and boys with their soldiers forced their way into a peasant's yard they fell

like vultures upon the poultry in the yard, over chests and boxes; they barred the doors, they railed, threatened, and tormented; they got into the beds and what they could not consume or plunder they destroyed; if a copper vessel was too large to take with them, they banged it in. When they broke up, they forced the host to put to and drive them to their next quarters. Then they filled the carriage with clothes, beds, and the household furniture of the peasant, and whatever they could neither pack nor sack they rolled up in their coats and round their bodies.

"When the horses have been harnessed to the carriage, women, children, and wenches fall upon the carriage like a bevy of crows. The wench who enters the carriage first takes the best place, then comes the servant of her lord with his bundle which is so full of stolen goods that a horse can scarcely bear it. The wench takes her seat upon it at once. So they fall one upon the other.

"If a married woman, the wife of a soldier, finds no place left and has to go on foot, she cries: 'Oh, thou shameless wench, thou, forsooth, must drive in a carriage, and yet for many years I have been the wife of a soldier, many a campaign have I made with him, and thou, slut, wouldst lord it over me.'

"The wenches and the women then fall upon one another, there are blows, stones are thrown, and when the baggage servant has tickled himself with this spectacle for a while, the wife of the soldier rushes to her husband, her hair streams

from her head, she screams out: 'Look you, Hans, there is a wretched wench, this fellow's baggage, who sits in the carriage and will drive, while I who am thy married wife must go on foot.' The soldier makes a plunge at the wench, would thrust her down and raise his wife to her place, but the fellow whose baggage she is comes up with his, 'Leave the girl in peace, she is as dear to me as thy wedded wife.' Then the soldiers fight among one another: daggers are drawn, men are hacked and pierced to death and maimed.

"This is of course no rare occurrence, for on the march scarce a day goes by without three or four or even ten soldiers losing their life and limb for the sake of their women.

"But when this fracas is over, and the woman is perched aloft, the carriages are often so heavily laden that the horses or oxen cannot move them from the spot, for as many as ten or twelve women and an equal number of children, and perhaps six boys, are seated among the heavy packages like caterpillars in a cabbage. And if the horse cannot get up the hill not one of them gets from the carriage, for instantly the other boys and wenches would leap into their places, and then there is not a devil alive who could dislodge them, for they say: 'Oho, the carriage is as much for them as for others; but they abuse the peasant with terrible curses, follow him and his cattle with blows, often four or six boys are round the wagon all throwing and beating. So have I seen oxen and horses sink dead in their harness.

"Thus the subject of the territorial lord has himself to drive the wenches and the goods and chattels which they have stolen from him.

"Often the wenches will not drive with oxen, horses have then to be procured over a distance of six miles to the great expense of the country people, and if they reach the next quarter with the equipage they do not let the poor people return to their homes, but they drag them away with them to be the slaves of other masters, finally they steal their horses from them, and with their aid make themselves scarce."

The surprising thing is, not that Gustavus was able to do no better in developing his army out of such material and under such conditions, but that he could do so well.

OTHER REFORMS DUE TO GUSTAVUS

As already noted, Gustavus invented his remarkable leather cannon during this war, and revolutionized field artillery with them; but he did almost as much in improving the muskets of the time, and in the same way—by lightening them.

The old match-lock musket, or *Gabelmusket,* as it was called, was over six feet in length, and fired a ball weighing one-tenth of a pound. Besides this ponderous weapon the musketeer carried a sword, a broad bandolier with eleven pouches for ammunition, and a stick with metal point and surmounted by two metal horns on which he rested

the gun in firing. For protection he still wore the heavy metal helmet.

Thus burdened, the musketeers obviously could not move quickly from place to place. Gustavus increased their mobility and effectiveness by lightening all of their equipment. He shortened the guns and lessened their caliber so that the forked stick was no longer necessary; and he replaced the flapping bandoliers with paper cartridges carried in a pouch like the modern cartridge box.

So the musketeers became at once a more important branch of the service. They could load and fire more rapidly, carried more ammunition, and could move about as quickly as any unmounted troops. They were still vulnerable to light cavalry which could move quickly to the attack, but they soon demonstrated their superiority over the old-fashioned heavy armored horsemen, plumed and armed with the traditional lance, causing that type of trooper to disappear forever from battlefields.

To resist the attacks of cavalry and for close fighting the old-fashioned heavily armed musketeer had required the support of the pikeman. But with the advent of the more lightly equipped musketeers, the pikemen became a useless branch of the service. They were too heavily equipped to move rapidly, either to attack or repel an attack, and, because of the general lightening of the equipment of the other soldiers, they became practically useless before the end of the war. They

did not entirely disappear, however, until the end of the seventeenth century.

A contemporary chronicler of this time thus expresses the view of the unfortunate pikeman:

"A musketeer is truly a much vexed, miserable creature, but compared with a wretched pikeman his life is splendid and happy. It maketh a man sulky to think what these good kerns endure of adversity; not a man will believe it who hath not himself been through the lesson, and I am of opinion that he who lays low a pikeman whom he might spare, murdereth an innocent man and can never again make good such a death blow. For although these poor, burden-shoving oxen—such is the contemptuous name by which they are called —were created to protect their brigades from the onslaught of cavalry in the open field, yet on their own account they do never a harm to anybody, and it is the fellow's own fault who runneth against the long pike of any one of them. In short, I have seen many sharp encounters in my days, but rarely have I known a pikeman to be the ruin of anybody."

The cavalry gained in importance as it was lightened in equipment, and Gustavus took active steps in introducing and encouraging lighter horsemen.

In the German armies before the time of Gustavus there were four sorts of regular cavalry: those completely armed and carrying lance or pike, a dagger, and two heavy pistols in the saddle; cuirassiers with a similar array of protective

armor, pistols, and daggers; arquebusiers, later known as carabineers, armed with steel cap and shot-proof breastplates, with two pistols and a hand musket slung on a small bandolier; and finally the dragoons, mounted pikemen or musketeers, who fought on horseback as well as on foot.

Added to this were the regular cavalry regiments of Croats, Stradiots, and the Hussars, who, nearly a hundred years before, in the year 1546, had made a reputation in Germany when the Duke Maurice of Saxony lent them from Bohemia to King Ferdinand. At that time they presented a rather pleasing appearance. They were armed in the manner of the Turk, carried scimitars and targes; but they had fallen into disrepute, being regarded as wild robbers.

Gustavus Adolphus brought only cuirassiers and dragoons to Germany, the cuirassiers being lighter armed than the Imperials, but far superior to them in the energy of their attack; and during the whole life of the Swedish king his efforts were directed to lightening the weight of the cavalrymen's equipment. For the more the armies became reduced to marauding bands the more urgent became the necessity for greater mobility. And the advantages of light equipment were thus made evident.

II

THE DEVELOPMENT OF SMALL ARMS

WHILE the improvements in cannon were being made, a corresponding improvement in small arms was in progress.

The first of such weapons was the " gonne," or hand cannon, which was simply a short metal tube fastened to the end of a straight stick, the whole being light enough so that it could be carried by the foot soldier or horseman. In firing this hand gun the soldier held the stick under his right arm, supporting and pointing it with the left, and touching it off with the match held in the right hand.

The horseman, whose weapon had a much shorter stick, held the end of this against his shoulder and rested the end of the piece in a forked iron fastened upright to the pommel of the saddle.

During the reign of Henry VII (1457-1509) the method of firing the hand gun was improved by the introduction of the fire-lock or match-lock.

This lock was simply a mechanical improvement of the older method of touching off the piece by a lighted match. The " match " of this lock was carried in a curved lever fastened at the side of the gun and arranged so that by pulling its lower

end, or trigger, the match descended into a small cup-shaped receptacle, or firing pan, which was placed at the side of the gun, allowing the soldier to obtain a more or less accurate aim by sighting along the top of the barrel.

About this same time an improvement in the shape of the stock was made also, and a stock resembling that of the modern gun, although much heavier, came into use.

By these two improvements better marksmanship was possible than with the weapon with the stock made of a straight piece of wood; and with the lengthened barrel which soon came into use, a very effective weapon was produced.

These early guns, however, were so clumsy and heavy that the musketeer, or *harquebuseer,* carried besides his weapon a forked rod upon which he must necessarily rest the piece while aiming and firing.

The great disadvantage of the match-lock lay in the fact that it was not always ready for use even when loaded and primed; for excepting in battle, or in the immediate anticipation of battle, the firing match was not lighted; and in the days before the introduction of lucifer matches, obtaining a light was sometimes a difficult matter. In wet weather also it was often impossible to keep the match and the priming powder dry. Efforts were made, therefore, to invent a lock in which a spark could be produced mechanically to ignite the powder in the firing pan without the use of the match.

These attempts resulted in the invention of the wheel-lock, which came into use in the form of pistols as well as guns as early as the beginning of the sixteenth century. It is said to have been invented in Nuremberg in 1515.

WHEEL-LOCK AND PISTOL

But while the wheel-lock was an improvement over the match-lock in that it could be discharged at any time by simply pressing the trigger, it was complicated and unreliable.

The principle upon which the firing of the wheel-lock depended was that of a rough-edged metal disk rubbing against a flinty substance, producing sparks which ignited the powder in the firing pan. The substance first used for this purpose was not flint, which was to become so popular a little later, but was the sulphuret of iron, or iron pyrites. The lock was so arranged that the piece of this was held in the firing pan by a spring and another spring was attached to the metal disk, which, after being wound up with a key carried for the purpose, could be made to revolve suddenly against the pyrites in the pan by pulling a trigger.

The uncertainty of this discharge was so great, however, that the wheel-lock probably never completely supplanted the match-lock excepting in its application to pistols. It was the flint-lock, rather than the wheel-lock, that supplanted the match-lock.

The importance of the part played by the

wheel-lock in the development of modern weapons, therefore, lies in the fact that it made possible such a hand weapon as the pistol. The wheel-lock pistol, though unreliable, was more effective against armed soldiers at close range than any weapon hitherto known. Mounted soldiers armed with these pistols could ride close to their antagonists, particularly the armed knights who carried no missile weapons, and while keeping well out of range of the lance or sword stroke, could discharge their pistols with deadly effect.

As illustrating this effect and showing that it was recognized early in the history of firearms, there are old tapestries and pictures made as early as the beginning of the sixteenth century showing some knights in battle, a number of them armed with pistols, while their opponents are armed with swords and lances.

In every instance where the knight is pictured as discharging his pistol, the opposing knight is represented as falling dead, suggesting the vulnerability of armor to pistol balls.

THE COMING OF THE FLINT-LOCK

But perhaps the greatest improvement in gunmaking until very recent years was the invention of the flint-lock.

The first flint-lock in its crudest form was known as the *snaphaunce,* and was invented in Germany near the close of the sixteenth century. In this lock the iron pyrites of the wheel-lock

was replaced by flint, and the wheel was dispensed with, its place being taken by the hammer which by striking against the flint threw the spark into the firing pan and ignited the powder.

The *snaphaunce* was a decided improvement over the older wheel-lock, but its possibilities were not fully developed until 1635, when it evolved into the form of the modern flint-lock—a form it retained almost unchanged for two centuries.

The two essential parts of the flint-lock were the hammer and the firing pan. In the *snaphaunce* the flint had been held by the firing pan, the metal hammer striking against it in that position. In the flint-lock the flint was transferred to the hammer, held firmly in place by a thumbscrew. The firing pan was constructed of a piece of steel working on a hinge and held in place over the priming powder by a spring. When the pan was closed this piece of steel was fixed at an angle so that the hammer, on falling, impinged against its surface, at the same time forcing it backward upon the hinge and exposing the powder in the pan to the sparks.

This mechanism was so nicely adjusted that a shower of the sparks fell directly upon the priming powder, seldom failing to explode it if dry.

The powder in the firing pan was connected with the powder in the gun barrel by a small vent hole in the side of the barrel.

The advantages of this lock over the preceding forms were that it was simple, reliable,—at least

as compared with the wheel-lock,—and always ready for use. Furthermore, the gun fitted with the flint-lock could be loaded and fired much more rapidly because with the new arrangement of the firing pan priming by hand was unnecessary as the lock primed itself automatically, the powder escaping from the vent hole through the barrel and filling the pan in the process of loading. To reload the piece the soldier had only to raise the hammer, close the pan, pour the charge of powder into the barrel, and ram home the bullet.

The piece could then be discharged by simply pulling the trigger.

The flint-lock also helped in reducing the weight of muskets, as the useless weight of the wheel-lock, with its large pan, heavy spring, and winding device, were dispensed with. Large pieces of flint were found to be unnecessary, and these were reduced in size, and the hammer and the pan correspondingly reduced, until the lock of the best type of flint-lock occupied very little more space than the lock of the modern gun.

Nevertheless the flint-lock had many defects. It was particularly susceptible to dampness because of the impossibility of making the firing pan absolutely water-tight. But even with the powder in the pan perfectly dry the piece frequently missed fire, the explosion of the powder in the pan failing to ignite the charge in the barrel, causing it to "flash in the pan." This was likely to happen just at the wrong time—in cases of emergency where a quick shot might determine

the issue. Under ordinary circumstances, where the gunner might open the pan and examine the priming powder or replace it if necessary before firing, misfires were much less frequent.

What has just been said of the flint-lock musket applies also to the development of the pistol, which was simply a reduced musket with a handle shaped to fit the hand rather than the shoulder. The change in size and shape of pistols and minor modifications in them from time to time were as great as in the case of the longer weapon; but no essential advance over the gun was made in pistol manufacture until the American, Colonel Colt, revolutionized the weapon by his invention of the revolver.

BAYONET AND RIFLE

The slow process of loading and priming the early muskets made it necessary for musketeers to be provided with some other weapon for close fighting. The long pike was, of course, the ideal weapon for the footman; but the soldier with his heavy musket and the necessary supply of ammunition was so weighed down that carrying such an extra weapon as the heavy pike was out of the question.

To meet this condition the " bayonet " was invented,—so called because of the improvements made later at Bayonne.

The first bayonets were simply short swords that fitted into the bore at the muzzle of the gun.

But with this bayonet attached the piece could be no longer loaded and fired, and the time required for fixing the bayonet in the muzzle before it could be used was sometimes of vital importance in a fight at close quarters. This defect was finally remedied by the invention of the socket bayonet, modifications of which are still in use in all modern armies.

The socket bayonet supplied the soldier with a pike always ready for use, interfering very little with the loading and not at all with the firing of his musket. By the beginning of the seventeenth century it had taken the form still in use until a generation ago.

It is probable that the experiment of making horizontal grooves, or rifling, in the barrels of firearms was first tried, not as a means of increasing the accuracy of the weapon, but in the attempt to overcome fouling. In the early days of gunpowder, when the exact composition of an explosive that would give the maximum amount of power with the minimum residue left in the weapon had not been determined, the piece became so fouled after a few shots had been fired that loading with a tightly fitting bullet was very difficult.

It is supposed that experiments were made to overcome this difficulty by cutting grooves along the surface of the barrel, and in this way it was discovered that greater accuracy in shooting could be attained by a barrel so "rifled."

Whether or not rifling was actually discovered

The Evolution of the Pistol

1. English "Tower" flint-lock pistol—used by both sides in Revolution.
2. U. S. flint-lock pistol, model of 1816—a cavalry weapon.
3. U. S. flint-lock pistol, model of 1836—made until 1844.
4. U. S. percussion cap pistol of 1847—used until the Civil War.
5. U. S. Colt revolver, used 1848 to 1855—the first revolver.
6. Colt percussion cap revolver—the well-known weapon of the Civil War.
7. Colt "Cavalry" revolver of 1873 to 1892—single action.
8. Colt revolver of 1893—Spanish War type—double action.
9. Colt automatic pistol—latest side arms—now used by U. S. Army.

in this manner has never been definitely determined. It is certain, however, that rifling was invented as early as the first part of the sixteenth century. The invention seems to have been made by the Germans, as it is known that Augustus Kotter of Nuremberg and Gaspard Kollner of Vienna manufactured rifled weapons about 1520.

The barrels of these guns were made with two, three, or more grooves running spirally the length of the barrel. Some of these first rifles were probably made with straight grooves; but as it had been known for centuries that the accuracy and penetration of missiles—the arrow, for example—could be increased by giving them a rotatory movement, it is probable that the spiral rifling was tried almost from the first.

But despite the fact that rifles were recognized as superior in accuracy and penetration to smooth-bored weapons, they had one defect which was so difficult to overcome that, except as hunting pieces, they did not come into general use with soldiers for several centuries after the invention.

This cardinal defect was the difficulty in loading them—due to the fact that in order to get the effect of the rifling on the bullet it was necessary that the ball should fit the grooves tightly.

When so made it was difficult to force the bullet along the barrel in loading, this being particularly true in starting the bullet into the bore. It could be accomplished with reasonable facility with a short peg and a few taps with the mallet, and when once started the ball could be rammed

home easily with a ramrod; but loading in this manner was much too slow and complicated a process for the soldier. For hunting and for target practice this loss of time was of little consequence; but for the soldier it was so important a factor that the smooth-bore musket remained the popular military weapon until comparatively recent times.

There were regiments of riflemen on the continent as early as 1631, to be sure, but the rifle did not come into general use in any country until a period in the nineteenth century, antedating the introduction of breech-loading weapons by only a few years.

A century before this time, however, there were bodies of men, hunters and frontier fighters, who used the rifle exclusively, and learned to shoot it with marvelous accuracy. Such men were found in Europe among the hunters of Switzerland, but the best marksmen and the most accurate weapons were found among the frontiersmen in America. The part played by the American woodsman and his weapon, the long-barreled, flint-lock rifle, in conquering the American continent for the white man is familiar matter of record.

THE "LONG RIFLE," OR "KENTUCKY RIFLE"

The dense forests that covered the foothills of the Alleghanies played a very important part in developing the prince of flint-lock weapons, the

"long rifle," of the backwoodsman of Revolutionary times. For these dense forests sheltered the Indian, who, in his forests, could defy the ordinary musket.

The white man, armed with a less effective weapon than the long rifle, could not hope to cope with the Indian in his strongholds. In the open, a handful of grenadiers like those of Braddock, or Grant, with their "Brown Bess" muskets, could have defeated almost any number of Indian warriors. But in the forest, no body of white men, not even the backwoodsmen themselves, if armed with weapons of doubtful accuracy, could cope with anything like an equal number of Indians similarly armed. Their only hope of success lay in having a weapon of greater precision, and in learning to shoot it with unfailing accuracy.

They could never, as a class, hope to equal the Indian as a woodsman, but they could, and did, learn to excel him in marksmanship.

In a word, the very existence of the borderers depended upon their marksmanship. The hunter or Indian fighter, with his slow-loading piece, must kill with a single shot. The more dangerous and aggressive the foe, the greater need of good marksmanship. And the American Indian in the trackless forest, as an individual fighter, has probably never been equaled by any savage of another race.

The forests of the western borders of the Colonies were an ideal place for the Indians'

style of fighting. These forests were so dense and unbroken for thousands of square miles that the hunter might wander there indefinitely without finding an opening that gave him a clear view of the sky. Here the Indian was at his best. Skulking noiselessly from tree to tree he could follow his enemies for days, keeping constantly within striking distance, his presence unsuspected until some member of the party who had stepped aside from the main body itself, or loitered behind, had been cut off.

Even the main body itself could be attacked with little danger, the Indians disappearing into the forest if beaten off, and returning again and again to complete their work, without greatly exposing themselves to the effective fire of the white men.

Regular troops armed and trained after continental methods were helpless against such attacks. Most of the Indians killed or wounded at such battles as at Braddock's or Grant's defeat were not struck by musket balls, but by the bullets from the long rifles of the despised American rangers.

So long as the white man clung to the musket as a weapon, therefore, the great forests of the border and the lands lying beyond were practically closed to him. There was but one solution of the problem—the development of marksmen whose skill in shooting would offset the Indians' woodcraft. By taking advantage of the one defect of this otherwise almost perfect woodland

fighter—the fact that the Indian never did, and apparently never can, learn to equal the white man in marksmanship—the conquest of the wilderness, and the occupation of the fertile lands beyond, became possible.

For such marksmen an accurate weapon was an obvious necessity; and the "long rifle"—often dubbed "Kentucky rifle"—fulfilling this condition, was finally evolved and perfected.

The long rifle, like the longbow, deserved its name. Its length was usually five feet or more, the gun reaching to the chin of a tall man. The barrel was very thick and made of soft iron. The ball was small as compared with the army muskets of the time, the bullets running about sixty or seventy to the pound, as against the musket ball's sixteen. These bullets were round, and were not ordinarily rammed home directly over the powder, but had interposed a thin "patch" of buckskin or cotton cloth.

This helped in adapting the bullet more accurately to the rifling in the barrel, and also tended to prevent fouling.

The stock was small, and often delicately modeled, scooped out at the butt, and running the entire length underneath the barrel. The sights were of the usual open "crotch" and "block" type. The weapon was very heavy, and not well balanced, but was nevertheless easy to hold in "drawing a bead," and in accuracy, at short range, probably unsurpassed even by modern rifles.

To hunters of to-day, accustomed to the simple and rapid loading of modern firearms, the process of loading the long rifle seems slow and complicated. It consisted in measuring and pouring in the powder; laying the "patch," greased to facilitate the entrance, over the muzzle; laying on the ball and driving it home along the four-foot barrel with the slender hickory ramrod.

In cases of emergency the patch was omitted, but at best the process of loading was a relatively slow one.

Nevertheless, the celerity with which the expert backwoodsman could load and fire his rifle under most disadvantageous circumstances was highly disconcerting to his antagonists. An instance of this kind is told of Louis Wetzel, a famous Indian fighter of the backwoods. Wetzel—so the story runs—was surprised by a band of Indians, and having fired his rifle, took to his heels, closely pursued by four Indians. By loading as he ran, and turning and firing, he succeeded in killing three of his pursuers in succession. The fourth gave up the chase, declaring afterwards that it was useless to chase a man "whose gun was always loaded."

The rapid loading and firing of some of the soldiers of the American Civil War is scarcely less marvelous. Not many years ago General Kilpatrick, the famous cavalry leader, was accustomed to give exhibitions from the lecture platform of this quick loading and firing. With the ordinary muzzle-loading army musket he was able

to load and fire with a rapidity approaching that of the average soldier firing the single-shot Springfield breech-loader.

As the long rifle had been superseded many years before the time of official records of rifle shooting at standard targets, it is difficult to compare the shooting of such men as Boone, Brady, and Kenton with modern experts. The nature of the targets they fired at, however, speaks sufficiently for their skill. One of the principal amusements of the woodsmen was the shooting match, indulged in whenever a number of neighbors came together. On such occasions a favorite target was a nail partly driven into a tree. The test of skill was to drive this nail with a rifle bullet shot from a stand several yards away. For the marksman to strike the nail squarely on the head was considered good shooting; merely to "tick" it on one side, bending but not driving it, was fair shooting; while missing it entirely was inexcusably bad marksmanship.

Another favorite pastime was shooting at night with a lighted candle for a target, the marksman attempting to "snuff" the candle without extinguishing the light. To do this only the upper part of the wick must be struck, as hitting it a fraction of an inch too low puts out the light. To miss the wick altogether or to strike the candle was looked upon as very bad shooting. So the aim had to be very accurate indeed.

This practice was particularly useful to the woodsmen, who frequently hunted deer and other

game at night by torchlight, firing at the glint in the animal's eye.

Two skillful marksmen sometimes exhibited their prowess and their confidence in each other by alternately shooting pewter cups partly filled with whisky placed on the head, piercing the cup above the liquid without spilling it. In this and a score of other ways the long riflemen attested the marvelous accuracy of their rifles, and their no less marvelous skill in handling them.

During the Revolutionary War the British became so impressed with the shooting of some of the regiments of backwoodsmen that they hired continental regiments of riflemen, called *Jägers,* to offset this shooting; but so far as can be learned the shooting of such regiments did not compare favorably with that of the American hunters. But the lesson of King's Mountain, where the deadly long rifle won the battle, was soon forgotten, although it was again repeated, with even more disastrous results, at New Orleans in 1814.

Nevertheless the British clung to the smoothbore musket for another generation, not adopting the rifle as a general arm for her soldiers until 1857.

Napoleon for a time tried the rifled gun, but soon discarded it, preferring the old smooth-bore for his troops. In view of the proverbially poor marksmanship of the French soldier of that time, both at home and in Canada, it is probable that the Emperor's choice was a wise one. For the

average soldier could load and fire the smoothbore more rapidly than the rifle, and for poor marksmen one weapon answers about as well as another.

THE PERCUSSION CAP

Meanwhile a most revolutionary invention had been made in the firing lock of firearms—the invention of the percussion cap in 1807 by a Scotch clergyman named Forsyth. This was the first really significant improvement in almost two centuries. And although a quarter of a century elapsed before the importance of this invention was fully realized, it was destined, eventually, to revolutionize firearms. Indeed, it was this invention that made possible the modern magazine and automatic gun.

The principle of Forsyth's percussion cap was that of a small cup-shaped piece of metal, containing fulminating powder which detonated on being struck with the hammer of the lock. Such caps were first made of steel or iron, but subsequently of copper. For using this cap a metal tube, or nipple, was fastened permanently at the side of the gun, corresponding in position to the firing pan of the flint-lock. This nipple was hollow, communicating directly with the powder in the barrel, with a pin-hole opening in the top over which the percussion cap fitted closely. The hammer, retaining practically the same shape as the hammer of the flint-lock, struck directly upon

the top of the cap which contained the fulminating powder.

In this manner the spark was driven directly into the powder chamber through a confined tube, making detonation almost a certainty.

The many advantages of this new system of lock were obvious. It was little affected by dampness, the fulminating powder being protected and rendered practically waterproof by a coating of some kind on the inner surface. It could be carried for days or weeks in all kinds of weather and could be fired at any moment by simply cocking the piece and pulling the trigger. With the flint-lock, as we have seen, damp weather was always disastrous; while shaking it about, as in marching, even in dry weather, was likely to misplace the priming and cause misfires. This one advantage of the cap-and-nipple over the flint-lock would determine its adoption. But another important discovery was soon made—the cap-and-nipple gun shot farther, and recoiled less than the flint-lock, even with smaller charges of powder.

The explanation of this was simply that less gas escaped through the vent hole at the time of discharge, owing to the fact that the size of the vent hole in the nipple could be reduced to a mere pin hole, whereas in the flint-lock it was necessarily much larger.

Another feature of the new percussion cap-and-nipple lock that appealed to military authorities was the fact that the flint-lock could with slight

alterations be converted into a cap-and-nipple lock. To do this the top of the hammer had only to be changed slightly in shape and given a flat surface for striking the nipple, and the vent hole enlarged and given a thread, into which could be screwed the shoulder of the nipple. The spring mechanism of the cock and the trigger action remained the same.

The new lock was particularly adaptable to hand weapons, and until its invention no such thing as a reliable pocket pistol, in the true sense of the term, was possible. There were flint-lock pistols, to be sure, of all sizes, ranging from the long horse-pistol down to a "vest pocket" weapon; but in emergencies, necessitating the sudden drawing of the weapon, they were not reliable, being likely to catch the pan in the holster or pocket, throwing it open and making the pistol useless until reprimed. Furthermore, the space occupied by the pan was much greater than that of the nipple. So that the advent of a reliable pistol as an emergency weapon dates from the invention of the Forsyth percussion cap.

Incidentally, the decline of the saber as a favorite cavalry weapon dates from this time also.

GREENER BULLET AND MINIĒ BALL

Although, as we have seen, neither European nor American army men seemed fully to realize the importance in warfare of rifled weapons for some time after the demonstration of their su-

periority, the example of Swiss and American riflemen was gradually having its effect. A French officer named Delvigne invented a rifle in 1826 which partially overcame the difficulty in charging. He constructed the breech with abrupt shoulders, shaped so that the bullet, when hammered against it with the rod, expanded and filled the grooves.

By this arrangement a ball somewhat smaller than the bore could be used. But the hammering process was not only tedious, but so distorted the shape of the ball that the accuracy of its flight was interfered with, thus defeating the object of such weapons. This gun, therefore, never became popular.

But in 1835 an Englishman, Greener, turned his attention to the bullet itself, and soon produced a ball that fulfilled all the necessary conditions by expanding and fitting the grooves when the weapon was discharged. This bullet was oval in shape, and flattened at the back, with a conical piece of metal inserted in such a manner that the explosion of the powder pressing against the plug expanded the bullet to fit the rifling.

Trials of this form of bullet proved entirely successful, but the Greener arm was not accepted for use in the armies, "because the bullet was a compound one." Its superior accuracy over the army musket was admitted, and it could be loaded as easily as the smooth-bore weapon; but conservatism held out against it for many years.

Seventeen years later (1852), however, a

similar bullet, or one acting on the same principle, was invented by the Frenchman, Minié, and came at once into favor. Minié's bullet was a conical ball of lead, with an iron plug at the base, which acted on the same principle as the Greener bullet, by expanding the leaden bullet into the rifling of the barrel. The Minié ball, or the various modifications of it, became at once the favorite bullet, especially with sharpshooters, and held its place of favor until the introduction of breech-loading weapons.

It was the most dreaded bullet of the American Civil War, because of its accuracy, and its " singing " as it passed overhead was familiar to all soldiers, easily distinguishable from the " scream " of the musket ball.

Some tests of this new rifle, in comparison with the ordinary army musket, have been recorded by Paixhaus as follow:

" At a distance of two hundred eighteen and six-tenth yards, it was found that a target of rather more than two yards square was struck one hundred times in succession with the new musket, and only forty-four times by the old weapon, out of the same number of shots. At six hundred fifty-five and eight-tenth yards, which the common musket did not reach, the same target was struck twenty-five out of one hundred shots by the new musket, whilst a field piece firing the same number only struck it six times. At one thousand and ninety-three yards, when a field piece usually diverged six or eight yards from the target, the

new musket struck six times out of one hundred shots; and at this enormous distance, it was found in the case of an experienced marksman that three of his shots out of four took effect on a moderate sized target; so that in this case art did more than nature, for at one thousand yards none but a good sight could distinguish the object which the musket hit so accurately.''

Here, at last, was a practical army weapon of great precision; and for several years every nation had its sharpshooters equipped with Minié, or similar, rifles. Then the breech-loader was perfected, and, as we shall see in a later chapter, the Minié rifle was relegated to the museum, where its predecessors—fire-locks, wheel-locks, and flint-locks—had long found a resting place.

III

PROJECTILES AND ARMOR

IT was many years after the discovery of gunpowder and its application to cannon before suitable missiles were found to use in the crude wooden or metal tubes of the early artillery. The first of these were simply stones, rounded so as to fit the bore of the piece approximately, or used as nature had left them. But aside from the fact that such cannon balls did not fit the bore of the gun, and consequently could not be fired with any degree of accuracy, they had the disadvantage of shattering against the stone walls of fortresses, or, what was even worse, splitting to pieces in the gun itself.

To overcome these defects molded metal balls soon came into use, and the spherical shape quickly supplanted all others, because such balls could be fired with a fair degree of accuracy and could be rammed home along the bore of the gun with greater ease than any other form.

For use against loose bodies of troops, charges of smaller lead balls, or bullets, placed loosely in the bore of the gun after the manner of shot in a fowling piece, soon became popular; and sometimes these were used in combination with solid shot, thus combining the crushing effect with

the wider danger zone for troops in the line of fire.

But all through the centuries, from the first introduction of firearms to the present day, artillerists have striven constantly to produce more deadly missiles.

Some of these were designed simply for more general killing purposes, while others were for special uses, such as setting fire to ships or fortifications, cutting spars and rigging, or battering down walls. The different kinds of shot and shell that have been produced as a result of these efforts are numbered by scores. Most of them were of little importance, and have long since passed out of existence except as curiosities. But a few have come down from the earliest times, and, in modified forms, are still in use; while others, such as chain-shot and bar-shot, have only passed out of use within comparatively recent years.

Chain-shot and bar-shot were made by joining two solid shots together by a chain, a solid iron bar, or with two bars linked together midway between the balls. When used as chain-shot, or with the linked bars, such projectiles were fired from two cannon placed side by side, discharged by a single vent hole. In this manner the two shot, spreading apart in their flight, could be made to cut the rigging of a ship, or mow a swath through bodies of troops.

There were many modifications in this kind of projectile, such as in the form of two swords

linked together in place of a chain or bar, but this class of projectile was never used extensively, and was confined to special purposes.

CANISTER AND GRAPE-SHOT

A much more effective form of projectile was the case-shot or "canister." This was used at close range against bodies of troops, and was designed to take the place of small stones, nails, bits of iron, etc., frequently used in early times. The case-shot consisted of a light metal case, filled with small bullets, and having a small bursting charge of powder which was connected with a fuse. At close range it was terribly destructive to bodies of troops on land or on shipboard.

Another somewhat similar projectile was known as "grape-shot." This was effective at still closer range. It was simply a charge of small bullets held together loosely in a bag which could be rammed into the muzzle easily, but which burst shortly after leaving the muzzle, scattering the bullets in the same manner as shot are scattered by an ordinary fowling piece.

Except at very close range the charge of bullets scattered too quickly to be effective.

To overcome this defect various modifications were introduced, a common device consisting of two circular disks of wood slightly smaller than the bore of the gun, held together by a metal rod, round which the bullets were packed, the whole mass being inclosed in a canvas sack.

An improvement on this form, however, was made by an officer named Caffin, at the beginning of the nineteenth century, and remained in use until the introduction of the modern projectiles for rifled cannon. In Caffin's " grape-shot " the wooden disks of the older projectile were replaced by thin metal disks, piled one above another with a single layer of small bullets alternating with each pair of disks, which were made with indentations into which the bullets fitted. The whole projectile was held together by a central rod fitted with a nut, and was effective at a considerable distance, although the exact point of bursting could not be predetermined accurately.

EXPLOSIVE SHELLS

Shells, or hollow projectiles containing explosives, are known to have come into general use as early as the middle of the sixteenth century, and were probably known and used at a much earlier period.

Somewhat similar missiles were in use before the introduction of gunpowder, except that they were charged with Greek fire or some other combustible instead of an explosive. The ordinary shell consisted of a hollow iron ball charged with powder and having a hole for admitting the fuse. The general principle of this shell remained practically the same for several centuries, although there were constant modifications, such as improvements in the shape, the method of inserting

the fuse, and the position of the bursting charge.

Such shells were very effective against wooden ships and fortifications because of their liability to set fire to inflammable substances, and because of the destructive effects of the shell fragments.

For purely incendiary purposes, however, other forms of shells were sometimes used. One of these was a large-caliber shell filled with molten iron poured into the shell a few moments before firing, and allowed to stand until the opening had been sealed by the cooling of the surface of metal exposed to the air, leaving the interior mass still fluid. This shell was made sufficiently thin to burst on striking against any solid substance, such as the decks, masts, or the hulls of vessels, the hot metal spattering about and setting fire to everything it touched. It was much more effective, therefore, than red-hot pieces of metal which were sometimes used at close range for the same purpose.

Another projectile designed for the same purpose and known as a " carcase " was a hollow shell filled with some combustible substance which burned violently and was not easily extinguished —a veritable " Greek fire."

This shell was used solely for incendiary purposes, although a somewhat similar shell, a " ground-light " ball, was used for lighting up the enemy's position at night. These shells were only used at close range and usually thrown into a space where the enemy was suspected of attempting to approach by stealth, or used to detect

parties of the enemy's workmen. On striking the ground these shells burst into brilliant flames which burned for several minutes, lighting up everything about them for a considerable distance.

Another shell used for the same purpose was what is known as a "parachute-light ball," which was thrown into the air over a suspected position. This was a very complicated projectile, a small parachute with a fire ball attached being squeezed into a thin case fitted with a small charge of powder ignited by a time fuse. The explosion of this powder burst the shell covering the parachute, at the same time setting off the substance used for giving a light, so that the parachute with its torch floated off, illuminating the field below. Such projectiles as these are now seldom used, the modern searchlight having for the most part replaced them.

ROCKET, SHRAPNEL, AND ELONGATED PROJECTILE

Another projectile invented early in the history of gunpowder was the war rocket. This projectile differs from all the others in the fact that it is self-propelled. It is made on the principle of the ordinary rocket used for fireworks, and has a larger bursting charge designed for scattering grape-shot or shrapnel. In recent years these rockets have been little used in warfare except against tribes of savages under certain conditions; but similar projectiles are still used for

casting a line from ship to ship, or to and from shore. For this purpose they are ideal because their flight is slower and more uniform than a projectile thrown by an explosive from a gun. The rocket, dragging the cord after it in its comparatively slow flight, allows it time to uncoil without breaking; while a cannon ball under the same conditions would snap the cord at the start.

One of the most important projectiles still in use is the shrapnel shell, or "spherical cased shot," as it was first called. It was invented late in the eighteenth century by General Shrapnel and came into general use in the nineteenth century. In the battle of Vimiera in 1808, the British used these projectiles with telling effect against the French, and the general popularity of this form of shell may be said to date from that time. The shrapnel was simply a modification of the ordinary shell, having a quantity of small bullets added to the bursting charge of powder, and at first mixed loosely with it.

The effect of this shell was practically the same as that of grape-shot or canister, but it had the great advantage that it could be used at long range.

In the first shrapnel shells, where the bullets were mixed loosely with the powder, it was found that there was a liability to premature explosion, due to the friction between the bullets and the surrounding powder. To obviate this the bursting charge and the bullets were given separate compartments in the shell, and this arrangement

proved entirely satisfactory, and is the one still in use.

The effect of the introduction of rifled guns was as revolutionary upon projectiles as it was upon the guns themselves. This revolution was not so much in the kind of shells as in the shape and structure of new projectiles, solid shot, shells, and shrapnel remaining in use but in modified forms. When smooth-bore pieces were in use there was little chance for variation in size and shape of projectiles, the weight of the spherical shot being determined by the diameter of the bore. But with rifled bore came elongated shot.

The resistance afforded by the atmosphere to an elongated, pointed projectile was less than to a round one of equal diameter, whereas, the difference in the weights of the two might be very great. With this increase of weight in the projectile without a corresponding increase in atmospheric resistance, a greater velocity could be attained; and the increase in the velocity of the projectile allowed a flatter trajectory, which of course added greatly to the accuracy in firing.

Another important advantage of the elongated projectile over the spherical was the fact that its capacity for holding the bursting charge and missiles was greatly increased; the killing effect of the shrapnel fired from the rifled cannon, for example, being much greater than the shell of a muzzle-loader of the same caliber because of the increased number of bullets it carried.

In the muzzle-loading rifled ordnance a great

obstacle was encountered in manufacturing a projectile which would take the rifling of the piece in the way necessary to acquire the rotary motion. It is obvious that a projectile large enough so that it fitted the grooves tightly could not be forced along the barrel of the piece by ordinary methods of loading. To overcome this, but at the same time to insure the spin of the shot, the projectile was fitted with studs or ribs of some soft metal, such as copper, accurately placed so that they could run in the grooves of the rifling.

By this arrangement loading the piece was made comparatively easy, but there was still the defect that there was a great amount of "windage." The studs of the rifling overcame to a certain extent the rebounds of the projectile in the barrel, but there was a considerable loss of power due to the escape of gas about the shot.

The escaping gas not only represented so much lost energy, but had a deleterious effect upon the metal of the barrel.

To overcome this a soft metal ring, or disk, of copper was placed at the base of the projectile, so arranged that the explosion of the powder acting upon it spread it, causing it to fill the grooves at the instant of firing before the inertia of the shot had been overcome. This device, known as a gas check, was found to work very satisfactorily in preventing the escape of gas. It was found also that it would act in rotating the projectile, so that the studs were no longer necessary on projectiles fitted with this type of gas check. The studs,

however, did not go out of use entirely until the general introduction of breech-loading cannon.

There was another great advantage in the use of soft metal gas checks. In the rifled weapon, through the bore of which the metal projectile is squeezed with great force at each discharge, there is unavoidable wearing of the rifling, and a slight increase in the size of the bore. With the studded projectile this was difficult to overcome, the loosely fitting shot increasing the windage so that the gun that had been in use for some time gradually lost some of its energy in propelling the projectile.

When the soft metal gas check was used, however, this difficulty could be overcome simply by increasing the thickness of the band of copper at the base, thus maintaining a uniform range and accuracy of the gun.

ARMOR-PIERCING PROJECTILES

The introduction of armor plates, which resisted the ordinary shot and shell projectiles, necessitated the introduction of a new projectile.

One of the first of such projectiles was designed by Major Palliser in 1863,—a projectile so satisfactory that modifications of it are still in use. The Palliser projectiles were explosive, but were not dependent upon a fuse for their explosion. The bursting charge contained in the shell was so arranged that at the moment of discharge of the cannon this charge flew back against the base of

the shell and was compressed into a solid cake and held there during the flight of the shot. At the moment of impact of the shell against some solid substance, such as the side of the iron battle ship, the exploding charge was thrown against the anterior walls of the chamber containing it, the friction and heat thus engendered causing it to explode.

The destructive effect of such shot, fired with sufficient velocity to pierce the iron side of the older battle ships, was enormous, the shell exploding at the moment of piercing the plate, sweeping everything before it.

Owing to the great improvement which has taken place in the manufacture of armor since the time of Palliser's invention these shells have gradually been supplanted for use in armor piercing. Shot specially hardened have been introduced, but the Palliser projectile, or a similar type of shell, owing to its simplicity and its relative cheapness, is still in use, for certain purposes, with certain modifications to meet new conditions that have arisen.

The projectiles in use at the present time in modern breech-loading ordnance differ very little from those used in the best type of rifled muzzle-loaders.

Constant improvements have been made and are being made in the details of their structure, and in the explosives used in them; but these details do not materially affect the general principles involved. Common shells, shrapnel, case-shot, and

armor-piercing shot are still the projectiles of the artilleryman. Every country has its own peculiar ideas in the manufacture of these projectiles, and all are attempting to improve upon them; so that, obviously, any attempt to give any detailed account of the different projectiles used in various countries is far beyond the scope of the present work. It will suffice for our purpose, therefore, to give a general description of the more common types of modern projectiles in use by some of the leading powers.

What are known as the "common" shells are simply modifications of the hollow projectiles filled with explosives and fitted with a fuse placed either in the nose or the base, which are dependent upon the destructive effects of their explosion for their efficiency. They are made, therefore, with the greatest possible cavity for containing the explosive consistent with the necessary strength of the shell wall.

Case-shot are made of thin metal cases made sufficiently strong to resist the action of the discharge without breaking and are filled with small bullets and a small explosive charge. They are fitted with time fuses which cause them to explode at certain distances, or with percussion fuses which explode them at the moment of impact against some resistant body.

Shrapnel shells, like the case-shot, are essentially man-killing projectiles of little use against fortifications or protected troops. They are, however, ideal projectiles for field guns, which now

use them to the exclusion of all other forms of shells. The great advantage of this kind of shell over the case-shot, for example, is that it can be fired with great accuracy at long or short range and timed to explode at any desired point. The bursting charge of the shell is at the base, the shape and structure of this base resembling the breech of the old-fashioned cannon. In front of this bursting charge are the bullets, almost filling the shell, the whole held in place by a top piece, into which the time fuse is inserted communicating with the bursting charge by a tube through the center of the shell.

In firing this shell the fuse is set so as to ignite the bursting charge sixty or eighty yards short of the target.

At the moment of discharge, therefore, the shrapnel shell is in effect a small howitzer firing grape-shot at point-blank range. The bullets so fired stream forward in a cone-shaped shower covering the large circular area with most destructive effect.

Another recent type of shell is one containing a high explosive, an example of which became popular during the Boer War in South Africa as the *lyddite* shell.

This shell resembles the common shell in its general structure, being simply a hollow piece of metal containing a charge of lyddite. It is not used with the time fuse, however, but is dependent upon a percussion fuse for its explosion. Its destructive effects are due to the enormous energy

of the explosion of the lyddite, which is something like three times as great as that of ordinary powder.

The result of the enormous force of this sudden explosion is to shatter the shell into a great number of fragments ranging in size from mere splinters to pieces of three or four pounds in weight. A shell of the same size loaded with ordinary powder would be torn into fewer fragments of much larger size. The effect of the bursting of the lyddite shell, therefore, is the destruction of everything about it for a considerable distance, making it a most effective projectile.

Lyddite is only one of several high explosives either in use or being experimented with at the present time, but the principle upon which all such explosives act is the same. Both Russians and Japanese used similar high-explosive shells in their recent war, the explosive used by the Japanese being even more powerful than that of the British lyddite. The use of explosives in the still more recent European conflict will be referred to more at length in another connection.

STEEL ARMOR

The struggle for supremacy to-day between armor and projectile is the same in modified form that has been going on always between methods of attack and defense. Neither one has been able to gain and maintain a material advantage for any very great length of time, improvements in

one always producing compensating improvements in the other.

On the general introduction of iron for armor plating two great difficulties were encountered in both plates and projectiles. Hard iron or steel plates were easily shattered and rendered worthless by shot, while the same impact shattered the shot itself, preventing penetration. Soft, tough iron plates could not be shattered, but they failed to shatter a hard steel projectile, and unless made of great thickness could be pierced.

On land this difficulty was not so serious, but for the turrets and armor belts of battle ships there was necessarily a weight limit, and a combination of some form of metal that was both hard and tough was diligently sought. Steel had so many advantages, however, that particular attention was given to discovering some method of rendering it tougher without lessening its hardness too much.

At first steel plates were cemented on wrought iron backs, such compound plates giving fairly good results; but as a rule the wrought iron failed to give adequate and dependable support to the steel facing.

Naturally this arrangement suggested the possibility of producing tough armor with a hardened surface in a single piece of metal; and very shortly Captain Trisidder in Europe, and Harvey in America, solved this problem independently.

By the time when Trisidder and Harvey discovered the process of hardening the surface of

steel, some advantage seemed to have been gained by projectiles over armor. But this advantage lay in the fact that it had become possible to harden the point and outer surface of steel projectiles—the desideratum sought in the manufacture of armor. This hardening process of the surface was accomplished by treatment with water and oil, the surface of the projectile becoming hardened while the interior remained tough and relatively soft.

But about 1890 Trisidder and Harvey discovered independently that by applying streams of water to the heated surface of a tough steel plate it would harden to a depth of several inches.

The processes employed by the two discoverers were somewhat different in details, each having its advantages and its defects, but the two soon became combined, and the resulting "Harveyed" or "Harveyized" steel was adopted for armor plates in Europe and America about 1892.

Against this new armor the hard-shelled projectiles were shattered without very great penetration and without cracking or shattering the plate.

By a curious accident, however, it was discovered that there was a way by which a steel shot would pierce Harveyed armor. If a plate of soft iron of some two inches in thickness was placed over the hardened skin of the plate and a steel shot fired against it, the plate that had resisted such shot could now be perforated. The explanation of this anomaly lies in the fact that the iron,

which was soft enough to be pierced by the point of the shot, affords sufficient lateral support to prevent the shot from shattering.

In other words, here was the paradox of a Harveyed steel turret of thickness to resist steel shot, and thus invulnerable, made vulnerable by the addition of a greater thickness of metal.

Naturally this discovery at once suggested the possibility of combining the layer of soft iron with the hard skin of the shell itself; but although such attempts had been made even before the discovery of the Harvey process, it was not until 1894 that shells of this kind were perfected. Such caps of soft metal on shot are of course necessarily thin and do not act as effectively as when a wide belt of metal is placed over the armor; but nevertheless, they are very effective, and have served as a check to the momentary advantage gained by armor.

The discovery of the Harvey process for hardening armor was followed almost immediately by another even more important one. At the same time that Trisidder and Harvey were perfecting their processes, experiments were going on at Annapolis with steel plates containing a certain per cent. of nickel, which was found to give toughness to the steel without preventing hardening of the surface. Nickel steel was therefore introduced tentatively into American armor.

The process of manufacture of nickel steel, however, was not entirely satisfactory, the results obtained being far from uniform at times, until

finally solved by the great German gunmaker, Krupp.

At the World's Fair in Chicago in 1893 Krupp exhibited some pieces of armor plate which had been tested with projectiles of various sizes. None of these projectiles had penetrated or cracked the plate. This exhibit commanded the attention of the entire military world, and, further successful tests having been made, "Krupp steel" came into general use as superior to any other material hitherto devised for the making of armor plate.

IV

PROGRESS IN NAVAL GUNS AND PROJECTILES TO THE TIME OF THE BREECH-LOADER

THE advantage of cannon on shipboard was recognized early in the history of firearms, and what has been said in regard to the development of land cannon applies, with slight modifications, to naval ordnance as well.

With the cannon themselves there was practically no difference for many years, the modifications lying chiefly in the gun carriages. For many years after field ordnance had been mounted on wheels, the crude naval gun carriage, consisting of blocks of wood fastened together with lynch pins, and held in place on the deck of the ship by means of ropes, remained in use; and it was not until the reign of Queen Anne in England that any marked improvements were made in naval gun carriages.

Then the two-wheeled truck, and the four-wheeled truck came into use; and they remained in use, practically unchanged except for slight modifications, until recent years.

As early as 1637, during the reign of Charles I, three-decked vessels were used, one of these ves-

sels, the *Sovereign of the Seas,* carrying one hundred and two brass cannon arranged on its triple decks. At this time, and until about the end of the seventeenth century, the nomenclature of cannon was most complicated, and it was not until about the end of the seventeenth century that a simple method of designating the kind of cannon by the weight of the projectile came into use. Until that time such names as "culverin," "demi-culverin," "saker," etc., were used to indicate eighteen-pounders, nine-pounders, and six-pounders, respectively; and these were but a few of the endless variety of names applied to various types of guns from the little swivel cannon to the heaviest ordnance.

But soon after the beginning of the eighteenth century it became customary to refer to guns by the weight of their projectile or by the diameter of their bore, and this nomenclature has continued in use, with certain modifications, since that time. The heavier guns, such as the twelve-inch, are designated by the size of bore, while the smaller ones are named from the weight of their projectile.

Early in the history of cannon, changes were made in the method of loading naval guns to overcome conditions on shipboard which were not met with on land. The favorite method of loading land artillery was to introduce the powder by a long-handled scoop, or ladle, made in the form of the ordinary flour scoop fastened to the end of a pole long enough to reach from the muzzle to

the base of the gun, the ladle being just small enough to enter the bore easily.

In loading with this ladle the gunner scooped out the requisite amount of powder for the charge, thrust it along the barrel of the gun, and then by half a turn deposited it at the breech. The wadding and the ball were then rammed home against the powder.

But this method of loading was found to be very unsatisfactory on shipboard on account of the rolling of the vessel; and paper cartridges, containing the proper amount of powder for a charge, were used as early as the reign of Henry VIII in England; and cloth bags were substituted for the paper cartridges shortly after this time.

Between the time of the first three-decked battle ship and the beginning of the nineteenth century naval guns had been gradually assuming characteristic shapes, and the type known as the "carronade" had become the favorite one by the time of Nelson.

The name of the gun, taken from the name of the inventor, Carron, indicated the type of the gun and not the size of its bore or weight of the projectile.

The carronades used on Nelson's battle ships were thirty-two and forty-two-pounders, such guns differing from guns of corresponding caliber used on land, in being shorter and lighter in weight in proportion to the size of the bore, and in the method by which they were mounted on the gun carriage. In ordinary field pieces or fortress

guns, the cannon was attached to its carriage by means of trunnions,—that is, cylindrical pieces of metal projecting at opposite sides of the barrel which fitted into rings and grooves in the gun carriage. The carronade, however, had no trunnions, but in place of them an iron loop was cast on the underside of the gun a little anterior to its center of gravity, and through this loop a bolt was placed attaching the piece more or less securely to the carriage.

By this arrangement a vertical elevation or depression could be given the gun, just as in the case of guns fitted with trunnions; but the space occupied by the gun was less, and the shortness of the piece made it easy to load and train.

FIRING THE CANNON

For many years after fire-locks and flint-locks had been in use on small arms, the primitive method of firing cannon by a lighted match applied to the vent hole continued in use with little improvement. After loading the cannon it was primed through the vent hole by fine powder poured from an ordinary powder horn and was then ready to be discharged by the application of the match.

Later the method of priming was improved upon by making use of tubes or quills filled with powder and thrust into the vent hole.

In 1781, however, Sir Howard Douglas invented a flint-lock for use on the guns of his vessels, this

lock acting in practically the same manner as the flint-locks on muskets. The practicability of these locks was demonstrated in one of Rodney's battles shortly after, where the flint-lock cannon showed its superiority over the guns fired by the older method. In a short time, therefore, guns were equipped with flint-locks of various patterns, a favorite one being the double-flinted lock, also invented by Douglas. These locks remained in use for many years after the invention and perfection of the percussion cap, and it was not until about 1842 that the flint-lock was superseded by the percussion lock. Then the invention of a percussion lock for cannon by an American named Hidden proved so satisfactory that the flint-lock went out of use.

Several years before this time the flint-lock for small arms had passed out of use; but adapting the new percussion lock to heavy ordnance proved a more difficult problem. The same cap-nipple arrangement which worked so admirably on muskets could not be applied for discharging heavy ordnance, as the large vent hole in the cannon allowed such an escape of gas at the moment of discharge that it frequently destroyed the hammer, rendering the piece temporarily useless.

Different types of locks had been invented to overcome this vital defect, but none proved satisfactory until the invention of Hidden. He devised a lock which was so arranged that by a pull of the lanyard the hammer was made to fall upon

the cap, explode it, and slip instantly out of range of the vent hole.

The arrangement of the hammer of this lock was simplicity itself, no spring being used, the weight of the hammer sufficing to explode the cap. It was placed on the breech of the cannon immediately behind the vent hole, pivoted so as to work up and down in the manner of the ordinary hammer, but the pivot hole, instead of being the usual circular opening, was made in the form of a slot. By this arrangement the single pull of the cord that rotated the hammer about the axis formed by the pivot and the base of the slot also pulled the hammer out of range of the vent hole after striking the cap, the fraction of a second intervening between the explosion of the cap and the ignition of the powder in the chamber being sufficient time to allow this.

The Hidden hammer at once became the popular one among naval gunners, and for twenty years was practically without a rival.

About 1862, however, a new type of exploding mechanism came into use and quickly superseded the Hidden hammer. This was an arrangement called a "friction tube," whereby the necessity for a lock of any kind was done away with, the friction tube acting as a cap and lock combined. This tube was a modified form of the old quill, or tube priming, with the addition of a percussion cap at the top which could be exploded by the friction of a piece of wire arranged to rub against fulminating powder by a pull of the

lanyard. It could be used in the vent hole on any piece of ordnance, the tubes varying in length and size according to the thickness of the breech of the gun for which they were designed.

In using this friction tube the soldier whose duty was to fire the piece thrust the tube into the vent hole after the piece was loaded, and exploded it by a jerk of the lanyard. The tube was thrown away after firing, the gunner making ready another tube while the piece was being loaded, by simply fastening the lanyard to a fresh tube by means of a hook-and-eye arrangement made for that purpose. By this arrangement little time was lost between loading and priming the piece; for by the simple process of thrusting the tube into the vent hole the piece was ready for discharging.

On the introduction of breech-loading cannon the friction tube was replaced by the electric and percussion fuses, but friction tubes are still in use on some of the older cannon.

EARLY GUN SIGHTS

Even at an early day in the history of gunpowder crude sights were in use on some types of cannon; but it was many years after the perfection of accurate sights on rifles and smooth-bore muskets that such sights came into general use for heavy ordnance.

This is probably explained by the fact that the target of the artilleryman was usually a large one,

such as a fortress, a ship, or a body of soldiers, and not a single soldier as in the case of the target for musketeer or rifleman, and accurate aim was not considered essential. The gunner, therefore, laid his piece by pointing it in the direction he wished to fire, taking a rough aim by sighting along the top of the barrel in an imaginary line parallel with the bore of the piece. With such a weapon as the musket, where the external surface of the barrel was practically parallel with the bore, something approximating accurate aim might be taken in this manner even without sights; but in the case of heavy ordnance, where the surface sloped from the thick base to the comparatively thin muzzle, even approximately accurate aim was out of question.

It was many years, however, before any kind of sights came into use, particularly on naval ordnance, where the movement of the ship interfered with accurate shooting.

By the end of the eighteenth century, sights were coming into use for cannon used on land, but naval men still rejected them. In 1801 Lord Nelson gave as a reason for rejecting sights the fact that his ships "would be able, as usual, to get so close to our enemies that our shot cannot miss the object." Nelson's view expresses the sentiment of the leading naval men of the time, and the record of his gunners was a sufficient answer to all arguments. Furthermore, in view of the erratic shooting of the short, smooth-bore cannon used on shipboard at the time, it is prob-

able that accurate aiming by the gun sight would have made little difference in the number of hits scored; and the time lost by such sighting was most precious in the heat of an action where firing was at point-blank at only four or five hundred yards at most.

The amount of vertical elevation or depression, however, had been roughly provided for at that time by the arrangement of the gun carriage so that the gunner had simply to point his piece within the space measured by the length of the enemy's ship—a comparatively easy thing to do even without sights.

EARLY NAVAL GUN CARRIAGES

Until our own generation the changes in naval gun carriages during the two preceding centuries were of little importance, the general type remaining the same during that time. Guns of the carronade type, with a loop and pivot in place of trunnions, required a somewhat different type of carriage from the trunnion guns, but this was an unimportant detail not affecting the general principle involved.

The ordinary naval gun carriage was made in the following manner: The sides were made of two heavy pieces of timber, called brackets, held together by a cross-piece on which the trunnions rested in grooves cut in the top for that purpose, being held in place by straps or loops of metal. The brackets were cut into three or more steps at

the top and back, so that an iron bar resting on these steps, and passed under the breech of the gun, could be used for elevating the piece, and could also be used as a lever for training it from left to right. But this iron bar, or handspike, was not used in maintaining the elevation for firing, but simply for raising the breech so that the "quoin," a wedge-shaped block of wood, could be slipped under to the proper place for obtaining the correct elevation. This quoin was marked in degrees, so that, the distance of the target having been determined, the elevation was obtained quickly by sliding it into the point indicated by the markings.

It was this arrangement, referred to a moment ago, that made it necessary for the gunner to guess at the elevation in training the gun, as that was fixed by the quoin.

The recoil of the gun was controlled by ropes, passed through an eye made for that purpose on the breech of the gun, and fastened to the sides of the vessel by rings or staples. This rope arrangement was called the breeching, and was given a sufficient length so that it stopped the gun in its recoil at a point where the muzzle was just inside the post, and in a favorable position for loading.

INTRODUCTION OF RIFLED GUNS

Such was the condition of guns and gunnery until about the time of the Crimean War.

Then activity in gunmaking was revived, rifled weapons were introduced, and with them began the struggle between modern armor and modern projectiles which has gone on unceasingly ever since, each improvement of one necessitating compensating improvements in the other.

The development of the rifled cannon was necessitated by the introduction of iron plate protection on battle ships. The damage done to wooden ships by the shells thrown into them during the Crimean War aroused naval men to the necessity of protecting ships against these missiles. A solid shot which pierced the hull of a vessel was of relatively little consequence in comparison to a shell which burst and set fire to the ship or drove the gunners from their positions by its smoke. To guard against this, plates of iron came into use on the hulls of vessels; and such plates, even when comparatively thin, resisted the spherical shot of the smooth-bore guns fairly well.

To meet this advantage gained for the moment by armor, attention was turned to improving the smooth-bore cannon, which had until that time been giving satisfaction for some five centuries.

The most vital defects in the smooth-bore were its inaccuracy and comparative loss of energy in discharging the projectile. These were caused by what is known as the "windage,"—that is, the difference between the size of the bore and the size of the projectile. While this difference was comparatively slight in well-made guns and

closely fitting projectiles, it was sufficient, even with the most perfect cannon and shot, to cause great loss in velocity, and irregularity in the flight of the projectile. The spherical projectile thus lost energy in the barrel by escape of gas between it and the bore.

The irregularity of its flight was caused by the series of irregular rebounds which it made in the barrel of the gun before leaving the muzzle. As it was necessarily a trifle smaller in diameter than the bore, its center, as it rested against the powder, was slightly below the center of the bore. At the moment of discharge, therefore, the upper surface acted upon by the powder was larger than the lower. For this reason the ball was driven downward in the barrel at the moment of discharge; but the rebound threw it at once against the upper surface, which again caused it to rebound, and so on along the bore, its passage along the barrel being a series of irregular rebounds which deflected it at the muzzle.

Furthermore, the bounds and rebounds were not confined to the vertical. For the axis of the ball as it rested in the chamber was not only lower than the center of the bore, but almost invariably to the right or left of it, so that the gas pressure at discharge caused it to rebound along the barrel in a most erratic manner.

The particular rebound as it left the muzzle determined the deflection in its flight, which at long-range shooting might mean a variation of several yards before reaching the target. There

was no way of overcoming this or of determining in which direction the last rebound might send the projectile, so that shooting with any great degree of accuracy was out of the question.

The same deflection occurred if an elongated projectile was used in a smooth-bore gun, with the additional disadvantage that such a projectile tended to turn over and over in its flight, possibly striking sidewise against the target, and thus offering a greater resisting surface than the spherical projectile. If it could be kept point foremost, a conical ball was, of course, an ideal shape for armor piercing and by giving it a rotary spin this could be accomplished. Both these things were possible in a rifled bore where the grooves were cut spirally in the barrel. But gunmakers in all European nations had been experimenting many years with such rifled weapons before anything like satisfactory results were obtained.

Two officers, Wahrenhorff, a Swede, and Cavalli, a Sardinian, each invented a breech-loading rifle cannon about 1846. But although these guns shot with greater force and accuracy than the ordinary smooth-bore, they had some minor defects and were never perfected.

In 1854, however, William Armstrong (afterwards Lord Armstrong) submitted to the British government a design for a new type of rifled cannon, which was at once adopted. It departed from the guns then in general use in three particulars—it was a "built-up" gun, a breech-

loader, and rifled. And while it was destined presently to go out of use and be replaced by rifled muzzle-loading pieces, it was, nevertheless, the prototype of the built-up breech-loader now in use all over the world.

The "building up" of the gun was necessary to make it strong enough to withstand the strain of the detonation of the charge and the passage of the projectile along the grooves of the barrel, which it literally squeezed through. The ordinary gun, cast in a single piece of metal, was unable to stand this strain unless made of enormous thickness at the base. But the danger in making a sufficiently thick piece of casting lay in the liability to flaws, which could not be detected until at some future time the piece burst, probably with serious consequences.

In place of this heavy cast-gun, therefore, the built-up gun came into use.

Such a gun consists of separate rings of metal, "shrunk" on over each other, in jackets or layers, until the desired thickness of the gun is attained. In making such a gun the central cylinder is made with its outside diameter slightly larger than the diameter of the tube of metal that is to form the next jacket. When the jacket is heated its diameter is increased just enough to slip over the inner cylinder, so that on cooling it clasps it firmly. About this jacket another is shrunk on in a similar manner, and this building up by concentric rings repeated, until the required thickness is obtained, this thickness decreasing, of course,

from the breech, where the greatest strain comes, to the muzzle, where the strain is comparatively slight.

When all the jackets have been shrunk into place, the piece is bored out to the desired caliber, rifled, fitted with breech mechanism, and finished exteriorly.

The making of such a piece is subject to many variations, and is, of course, a much more complicated process than indicated by such a bare description of the principle involved. The kind of explosive to be used, the weight of the charge, the use of slow-burning or quick-burning powder, etc., are all determining factors in the manufacture of modern ordnance, but these are details that will be referred to later. The principle involved is unchanged, although in practice of gun manufacture there are constant changes and improvements.

As was said a moment ago, the Armstrong breech-loading cannon came into use shortly after the middle of the last century. It threw a lead-coated, iron projectile, the lead jacket fitting tightly into the rifling of the gun, thus centering the projectile and doing away with the windage, at the same time causing it to rotate, and so keeping it point foremost at all times. This cannon was, therefore, more accurate and of longer range than its predecessors. But as yet the breech mechanism was so crude that there was practically little saving in time by this method of breech-loading over the best type of muzzle-loaders.

There was, moreover, an element of danger connected with the use of a gun with a loose vent piece, and this danger was so great that these guns, of the larger natures, were soon replaced by muzzle-loading rifles.

In the bombardment of Kagosima in 1863 by the British, several of the breech pieces of the heavy guns were blown out, due to the fact that in closing they had not been screwed home tightly. The possibility of this occurring in the heat of an action, with its disastrous consequences, led to the reintroduction of muzzle-loading guns, temporarily, as it proved, until a still more serious accident to this type of gun showed that there was even a greater danger in using the muzzle-loader than with the breech-loader.

By 1864 the British navy had decided to discard the heavy breech-loading guns, and while maintaining the same general principles as to building up the rifling, the heavy pieces were made with solid breeches, to be loaded from the muzzle. Many difficulties had to be overcome, particularly the windage, which was obviated with comparatively little trouble in the breech-loading weapon, but by 1875 these had been successfully overcome.

Guns of immense size and caliber were now made, some of the guns of the *Inflexible* being eighty-ton guns, firing a projectile weighing one thousand seven hundred pounds.

The land pieces eclipsed even these, and in 1878 two one-hundred-ton guns were built, with a caliber of seventeen and five-tenths inches.

H. M. S. "Thunderer" Leaves the Thames to be Commissioned

Within a year from this time, however, on January 2d, 1879, occurred an accident to one of the thirty-eight-ton muzzle-loaders on H.M.S. *Thunderer,* which settled the question of muzzle-loader *versus* breech-loader for all time, as it was shown that similar accidents were likely to occur at any time with muzzle-loading pieces. The *Thunderer's* turret guns were being fired simultaneously in practice, when, for some reason not apparent at first, one of them burst, killing or maiming the members of the gun crew. A board of experts who were appointed by the Admiralty to investigate this accident determined that it must have been due to double-charging of the piece. When the two guns had been run out for firing, one of them had missed fire; but this was not detected, as the concussion and smoke of the single discharge is so great in heavy ordnance as to make the difference between the discharge of one and two guns imperceptible.

Both guns were therefore run in, loaded, and again discharged, the explosion of the two charges of powder in the doubly-loaded gun causing it to burst.

The board of inquiry reached their conclusion as to how the accident occurred by purely theoretical reasoning; but to make sure the Admiralty had the remaining gun brought home and subjected to a number of tests. Every suggestion as to how the other guns might have burst except the double-loading was acted upon, but after firing again and again the gun still remained as

sound as ever. As a final test, therefore, it was doubly-loaded and discharged. When the smoke of the discharge cleared away it was found that the gun had burst into fragments practically the same as those of its unfortunate turret companion.

These tests settled beyond question the fact that double-charging was responsible for the accident; and as this had occurred in practice, and would be still more likely to occur in the excitement of actual battle, naval men once more looked to the breech-loading weapon as the safer of the two.

It was apparent that the weakness in the vent piece of the breech-loader could be overcome more easily than the possibility of double-charging the muzzle-loader.

In this connection it is interesting to note that similar accidents to small arms have occurred many times on battlefields—many more times than can be recorded in all probability—where muzzle-loading muskets were used. The soldier, forgetting to cap or prime his gun, or the cap exploding without firing the powder, would not notice the misfire of his weapon in the excitement and roar of the battle about him. Thus a new recruit in his first experience of being under fire might easily forget to cap his weapon until several charges had been rammed home.

Fortunately for such a soldier, the musket fires a relatively smaller charge than the cannon in comparison to the strength of the barrel, and even a triple-charged gun seldom explodes. The

force of the recoil from the overcharged gun, however, is terrific, sometimes stunning the victim, dislocating his shoulder, or breaking his collar bone. One case is recorded in the American Civil War of a musket picked up on a battlefield containing six charges of powder and ball. It was still uncapped.

What might have happened to its owner had he finally remembered to use a cap can only be surmised.

V

BREECH-LOADING SMALL ARMS

THE glaring mistakes made in military predictions are proverbial. And the person who has the temerity to predict what weapons are likely to be in use, or what methods will be practiced on battlefields a decade hence, is treading on dangerous ground.

An example of this failure of a prediction to materialize, showing how far "scientific guesses" may come from the truth, is shown by the history of the once much-heralded Minié rifle and bullet.

When this peculiarly effective gun and compound bullet were brought to the attention of military men, there were some among them who seriously predicted that this weapon would supplant light artillery, and revolutionize military methods. For the Minié rifle outshot and outpointed all the light artillery then in use. At the same time another rifle was being tried, which excited comparatively little comment. This was a single-shot breech-loading gun. But ultimately the predicted revolution was effected by this breech-loader, while the Minié rifle passed out of existence after having made only a ripple in the great stream of military progress.

Perhaps one reason for the lack of enthusiasm

over the first practical breech-loaders was because guns of somewhat similar type were not novelties at the time. Since the earliest introduction of gunpowder many different kinds of breech-loading guns had been invented; but as yet none of them had been brought to a stage of practical perfection.

There were breech-loading flint-lock guns of various patterns, for example, made during the latter part of the eighteenth century, and still to be seen in museums; but all of these were defective.

Indeed, there was little chance of inventing a really practical breech-loading military rifle until some means other than that of flint and steel was devised for igniting the charge of powder. Such a weapon was in use to a limited extent, to be sure; but later it was abandoned in favor of the old-fashioned muzzle-loader. This gun was the invention of John H. Hall, an American, who submitted his invention to the United States Government to be tested in 1818-1819. It was thought to be especially adapted to cavalry service, and some regiments were armed with this gun, which was manufactured at the armory at Harper's Ferry.

At this time the percussion cap was just coming into use, and the Hall breech-loader was so constructed that it could be used with these caps or as a flint-lock. It was fairly convenient for loading, and had a number of good points; but it had the vital defect that it was liable to be discharged accidentally; and after several accidents

of this nature had occurred the government finally abandoned this gun for the muzzle-loading carbines.

In the meantime other countries were making extensive experiments with breech-loading weapons, the Scandinavians in particular being successful. In these guns paper cartridges were used, and with such success that by 1845 the Prussian government asked that the Scandinavian gun be tested against the German muzzle-loader, which was considered one of the best weapons of the time.

In these tests the breech-loader showed that it was the equal of the older gun in range and accuracy, while in rapidity of fire it completely outstripped it.

As a result, a certain number of these guns were adopted in the German army, which was experimenting at the same time with the now famous "needle-gun"—another breech-loader, of much the same type. But both these guns had the same defect in the eyes of military experts. There was an unavoidable escape of gas at the breech which would, it was thought, render them useless in a short time. Nevertheless there were so many advantages of breech-loading weapons that, in Prussia at least, they gained in popularity, until the war of 1866, when the overwhelming superiority of the Prussian needle-gun over the Austrian muzzle-loader was made apparent to every nation.

Five years before this, to be sure, a breech-

loading repeating magazine weapon had been used successfully in the American Civil War. And had this war taken place on the other side of the Atlantic all nations would undoubtedly have been familiar with the Spencer carbine—the favorite weapon of the American cavalrymen. But at that time the older countries were loath to believe that there was much to learn either of weapons or warfare from across the Atlantic. And so the Spencer carbine, used in a greater war than Europe had ever had, by a greater number of cavalrymen than any European power possessed, did not attract the attention to which it was entitled.

But the few weeks of fighting in the Danish war of 1864 and the Austrian war of 1866, in which the needle-gun was used, brought that weapon into prominence at once.

The needle-gun, therefore, is the weapon directly responsible for the development of modern single-shot military rifles; and in many ways it resembled the military rifles of to-day. It was a rifle of the "bolt action" type, this type of breech system being the one still used most in military rifles.

The mechanism of this gun as described by a contemporary military writer was as follows: "It combines the use of percussion with that of a peculiar kind of ball, which being conical, cylindrical at the center, and round at the larger end, is a good deal heavier than a sphere of the same caliber. It becomes rifled as it passes through the

barrel, and is propelled with much greater force than the ordinary rifle ball, owing to two causes, *viz.*, a suitable center of gravity, and the more perfect ignition of the powder, which takes place in front, instead of behind, as formerly, at the other end of the charge, is accomplished by means of a metal needle and a spiral spring.

"The spring serves the purpose of a lock, and by forcing the needle through the charge, the fulminating powder explodes it."

The cartridge, as will be seen, was not made of brass or copper, as in the case of modern cartridges, but of heavy paper, sufficiently strong to hold its shape, but not firm enough to prevent the necessary piercing of the firing pin.

As compared with the cartridges and lock action of the Spencer carbine the needle seems crude indeed. The long needle of the lock had to plow its way through thick paper and the entire charge of powder before striking against the fulminating powder at the base of the bullet, while in the metal cartridges used in the Spencer gun the cap was placed next the plunger, and the "needle" did not come in contact with the powder at all. But shortly after the war of 1866 the Prussians adopted the American metallic cartridge, and as this got over the escape of gas at the breech, the needle-gun type of rifle became at once the favorite with most of the military nations.

It is true that during the War of the Rebellion several types of breech-loading and magazine guns besides the Spencers were in use to a limited

extent; but the majority of troops engaged were armed with muzzle-loaders to the last. This was not because the merits of the breech-loader were unappreciated, but because there was no time for experimenting with new weapons, or rearming the million and a half men in the field.

Nevertheless, during the period covered by the war, something like twenty-seven different varieties of breech-loading or repeating rifles and carbines were submitted to the government for trial. Some of these were excellent weapons, notably the Spencer carbines, and all the cavalry regiments were eventually armed with these; but most of the infantry regiments continued to use the muzzle-loader until the end of the war.

Breech-loading sporting guns had been in use for years before the adoption of the breech-loading military gun. But a type of gun which may be entirely satisfactory for the purpose of the sportsman does not necessarily meet the requirements of the soldier. In fact, there has always been, and still is, a general distinction between types of breech-loading sporting weapons and breech-loading military weapons.

Ability to stand rough usage is the essential feature of the military gun, which cannot be sacrificed for any minor defects; while in the sportsman's weapon this feature may be slighted.

As a result, very few of military rifles are favorites with the sportsman, and very few types of sporting rifles find favor in the eyes of military experts. But as we are directly concerned with

the military, rather than the sporting rifle, the numerous types must be ignored except as they have direct bearing upon the development of military guns.

Within five years after the close of the American Civil War practically every civilized nation had adopted some form of breech-loading rifle using the metallic cartridge. The individual patterns of these guns used by the various nations differed considerably in details of structure, but all conformed to one of three or four general types.

England, for example, had adopted the Martini-Henry rifle, with the breech mechanism known as the "block" action. In this gun, the block, or breech piece, which is fitted at the base of the barrel just in front of the trigger, contained the lock and the firing pin for striking the cap of the cartridge. This block was attached to a lever on the under side of the stock which, when pressed downward and forward, caused the block to fall in a vertical direction, at the same time throwing out the cartridges and exposing the chamber of the gun ready for loading. A reverse movement of the lever, bringing it backward and upward to its resting place against the grip of the stock, raised the block, and closed the chamber, at the same time cocking the piece ready for firing.

Thus only two motions of the lever, one forward and one back, were necessary for reloading the piece.

In this type of block-action gun, the block contained the hammer and firing pin. There was another type, however, where the block contained the firing pin only, the hammer and lock being in a separate piece. This was the Remington type of gun which was popular for many years in America and several European countries. To load this gun it was necessary to raise the hammer and open the breech block by two separate movements. Closing the breech was done by a single movement, the piece being ready for firing as soon as the breech was closed. It will be seen from this that loading the Remington required three movements, as against the Martini-Henry's two, not including the insertion of the cartridge. But this apparent advantage of the English gun was partially, if not entirely, offset by the fact that the open chamber of the Remington gun was much more accessible, and in practice the number of shots that could be fired in a minute with the two types of gun was practically the same.

The United States adopted a block-action gun, the Springfield rifle, having the hinge of the block in front.

In this respect the American weapon was unique, no nation of any importance having a gun that resembled the Springfield either in appearance or action. From an artistic point of view it was perhaps the most ill-favored gun adopted by any nation, the huge hammer and long breech block giving it an awkward appearance. On the other hand, this rifle was perhaps used more con-

tinuously in actual warfare under the most trying conditions than any other military breech-loader. For the Indian wars were practically continuous from one year's end to another on some point of the frontier, affording an opportunity for testing all manner of rifles, and it is perhaps sufficient proof of the excellent quality of the Springfield that it stood all these tests and remained in use as a weapon of the regular soldier until the modern small-caliber magazine gun supplanted all single-shot breech-loaders.

Three motions were required to load the Springfield just as in the case of the Remington. The first motion raised the hammer; the second opened the breech block and extracted the shell; while the third closed the chamber, making the piece ready for firing. The time required for loading and firing was practically the same as with that of the two-movement guns. In fact, the actual speed with which the various types of breech-loading army rifles could be loaded and fired was practically the same.

But while these various types of block-action guns remained popular in several countries for many years, " bolt-action " guns, typified by the needle-gun, were equally popular in other countries, notably Germany and France. In such guns the " bolt " consists of a metal box continuous with the lower end of the barrel of the gun, to which is attached a knob at the right-hand side. To open the breech this knob is given a quarter turn upward and drawn backward, this move-

ment extracting the exploded cartridge and cocking the piece. The reverse motion closes the chamber, and makes the gun ready for firing.

The knob has nothing to do with the lock mechanism proper, being simply a handle for opening and closing the breech.

There are various modifications in the internal mechanism of this bolt system, no two weapons of different types being exactly alike in this particular, but these differences are in details which do not affect the general principle.

The chief recommendation for this style of breech action—the all-important one from the soldier's point of view—is its stability and simplicity. It has the disadvantage, particularly when applied to magazine guns, that for reloading the soldier must take his hand away from the grip of the stock, manipulate the knob of the bolt in a somewhat awkward position, and again clasp the stock before he can fire. These motions are relatively complicated as compared with those necessary in guns working on the lever principle, or the "forearm movement," where the hand does not leave the grip of the stock at all during the reloading.

For extremely rapid firing, therefore, the bolt action is inferior to some others; but it is sufficiently fast nevertheless to meet all the requirements of any occasion likely to arise on the battlefield.

INTRODUCTION OF THE REPEATING GUN AND PISTOL

The single-shot breech-loader had hardly taken its place as a universally recognized military rifle, before it was replaced by the repeating rifle, or magazine gun.

As is generally understood, a " repeating " or magazine gun is one in which several charges are held in reserve, which may be fired in rapid succession without stopping to recharge the weapon. Such weapons had been in use many years before being finally adopted as military weapons, and magazine guns of a crude type had been known even as early as the sixteenth century. In the Tower of London, and in several other armories of ancient weapons, there are still examples of these early magazine guns. The one in the Tower is constructed on the general principle of the modern revolver, a number of chambers for holding the charges being contained in the rotary cylinder which discharges through a single barrel.

But such weapons, although so closely resembling the present-day revolver, were of little practical value; and had been forgotten, until made practical in 1835 by the invention of what is now known as the revolver, by the American, Colonel Samuel Colt.

From this date, therefore, begins the history of the practical magazine gun, or perhaps more correctly the magazine pistol. The excellence of the system is shown by the fact that the various types

of revolvers still in use in all armies throughout the world resemble very closely Colt's revolver of 1835, not only in appearance but in mechanism.

As early as 1830 Colt had invented a repeating rifle so arranged that a number of barrels, fastened together side by side and rotating about a spindle, could be fired in rotation by a single lock. This weapon had little practical value, however, as it was necessarily extremely heavy and awkward to handle. But in 1835 he hit upon the idea of making a rotating cylinder bored out into a number of chambers so arranged that they could be brought successively into line with the barrel of the gun. This was an old idea in itself, as we have seen, but Colt's entirely novel invention was his ingenious and simple device for causing the cylinder to rotate, and be temporarily held in position for firing, by the single movement of raising the hammer. Some time was required for the loading of this first revolver, but when once loaded it afforded a means of carrying from five to seven reserved charges, always ready to be discharged in rapid succession.

One such weapon, containing six chambers, was infinitely superior to six ordinary pistols. It occupied no more space than a single-shot pistol, and it could be discharged six times without removing the hand from the handle; whereas each pistol must be drawn and cocked separately. Besides this, the six chambers could be charged in much less time than that required to charge six separate pistols.

A soldier armed with a brace of such revolvers could discharge as many shots at close quarters as a squad armed with muskets; and the weight of the two revolvers was much less than a single musket.

For Indian-fighters on the frontiers, or for any purpose where rapidity of fire was required, this weapon was the most revolutionary innovation since the invention of gunpowder. Nevertheless, its merits were so slow in impressing themselves upon military men that the little company which Colt had formed for manufacturing his pistols failed because there was no demand for this weapon, after turning out a comparatively small number. And it was not until the outbreak of the Mexican War in 1847 that the revolver was fully appreciated, and the prosperity of Colt's reorganized company assured.

It is true that the merits of the revolver were recognized by the American frontiersmen from the first, but news traveled slowly from the outlying districts in those days, and although a certain number of soldiers had been armed with the new weapons experimentally even before the opening of hostilities with Mexico, it was not until war was declared that they came to be generally in demand. Then, suddenly, Colt's little company found itself overwhelmed with a flood of orders from the government, officers, and private citizens. In some instances fabulous prices were paid for the second-hand weapons on the market.

An American officer paid three hundred dollars

for one of these, and congratulated himself upon being able to secure it at any price.

By the close of the Mexican War, Colt had greatly improved his revolver by adding a ramrod that worked on a hinge attached to the barrel and was held in place beneath it when not in use. With this arrangement the danger of losing the ramrod was avoided, and an additional advantage was gained in that the new ramrod acted as a lever by which the bullets could be quickly rammed home by a single movement. With this arrangement the six chambers of the revolver could be loaded almost as rapidly as a single chamber of the long-barreled musket. The soldier carrying two of these weapons could, by loading them alternately, have at his command at all times at least six charges which could be discharged in about as many seconds if the occasion demanded it.

It is little wonder, therefore, that troops engaged in the Indian warfare clamored eagerly for "revolving pistols," as they were usually called at that time.

Following the war with Mexico a committee was appointed by the government to report upon Colt's weapon, and after making a series of investigations, which included asking the opinions of the leading military men, hunters, and Indian-fighters of the time, this committee reported favorably on the revolver on January 30th, 1851. To this report was appended a long list of letters written to the committee in reply to their requests

for opinions about the Colt revolver. Some of these are worth quoting.

Brigadier General Joseph Lane, commanding volunteers in Mexico, wrote: "I think I can say as much for and about this formidable weapon as anyone now living except Colonel Jack Hays of Texas. I have seen it tested in several severe and bloody conflicts, when a few men, armed with Colt revolvers, were equal to five, and in several instances ten, times their numbers. No weapon is equal to it. In close quarters one man is always equal to three or more. I know the use of it well, and would recommend that all mounted forces be armed with them."

Major General Gideon J. Pillow wrote: "In reply, I do not hesitate to say, I regard Colt's repeating pistol as the most formidable firearm with which I have any acquaintance, for all mounted troops.

"Indeed, I do not understand how its value can be doubted by any familiar with its use."

But the same glowing praises could not be given the Colt revolving rifle, although almost identical with the revolver except in length of stock and barrel. There was necessarily a loss of power in these weapons, due to the unavoidable space between the cylinder and the barrel, with a resulting escape of gas. It was, therefore, defective for long-range shooting—a most vital defect in a rifle. There was also an element of danger in using it, owing to the fact that more than one chamber sometimes exploded accident-

ally in firing. This did not happen frequently if the caps were closely fitted on the nipples, and even when it did occur with the revolver there was no danger to the person firing, as his hand, clasping the butt, was entirely out of range of the charge.

But in the case of the rifle or carbine, where the weapon was supported by the left hand held in front of the cylinder, there was constant danger that the accidental discharge of an extra cylinder, or possibly two, would seriously wound the wrist and hand. For these reasons the Colt revolving rifle never came into popular favor.

THE "DOUBLE-ACTION" REVOLVER

As we have seen, firing the chambers of the Colt revolver required only two movements, that of cocking the piece and pulling the trigger.

But this method of firing was shortly improved upon, so that a single movement of the trigger—a straight pull backward—raised the hammer, revolved the cylinder, and discharged the weapon. By this arrangement, which is known as "double-action," or "self-cocking," great rapidity in firing was possible. It had the disadvantage that the relatively strong pull necessary to work the trigger made it difficult to take accurate aim, but as the desideratum in such weapons as the revolver is rapidity, rather than absolute accuracy, the new system of self-cocking weapons soon came into general favor, and with one simple but rather

important modification is still the popular one the world over.

This modification consists in combining the single-action and double-action in the same weapon. By modifying slightly the shape of the hammer and the trigger a revolver could be made which might be used as an ordinary single-action weapon for accurate shooting, if desired, or as a double-action for rapid work; and this type of double-acting revolver is the one used by the navies and armies of the world at present.

The invention of the metallic cartridge revolutionized the loading process in the revolver just as in the case of the rifle, but in other respects it had very little effect in altering the general shape, mechanism, and appearance of the revolver in use half a century ago. In fact, with a slight alteration in the hammer and the base of the cylinder, the ordinary revolver could be converted into a weapon using metallic cartridges, and tens of thousands of revolvers were quickly altered in this manner.

But the loading process in such revolvers, while being a great improvement over the powder-and-ball method, was too slow to be entirely satisfactory, and various types of quick-loading weapons were shortly invented. In some of these, rapid loading was made possible by hanging the barrel and cylinder on a hinge at the lower part of the frame, so that by "breaking" or pulling the muzzle downward the cylinder was raised and the cartridge extracted at a single movement. The

exposed chambers could then be loaded by simply dropping the cartridge into place, the reverse movement of raising the barrel closing the piece ready for firing.

With such a weapon the cavalryman could reload with his horse going at full speed, using only one hand in the process. The defect in this type of revolver is that the frame is no longer a solid piece, and is sometimes injured by rough usage. In actual practice, however, this revolver has proved most satisfactory, and it is undoubtedly the most popular form of pocket revolver at the present time.

As a military weapon, the solid-frame revolver has remained the popular one; but the recent types of revolvers are so modified that the cylinder may be exposed for loading quite as easily as in the hinge-joisted weapons, without interfering with the rigidity of the frame. Such a weapon, which is a good example of the type, is the new Colt revolver in use in the United States army and navy.

In this weapon the cylinder is so made that it can be rapidly loaded by simply releasing a catch, allowing the cylinder to fall to one side, the empty shells being extracted all at one time by simply pushing a rod running through the center of the cylinder.

Reloading the five chambers is facilitated by having the cartridges fixed at their bases by a loader, or charging chip, which holds them in position so that a single movement charges all five of

the chambers. In this way the rapidity of charging and shooting the revolver is so perfected that little is left to be desired in the way of improvements. Furthermore, the mechanism is so simple that there is little danger of the weapon getting out of order, even with rough usage.

But notwithstanding the fact that the ordinary army or navy revolver may be fired with something like reasonable accuracy at the rate of six shots in less than the same number of seconds, inventors have recently perfected semi-automatic pistols with which this rate of firing may be greatly increased. Several such weapons, of various types, are now on the market and are found to work satisfactorily in actual practice. The principle upon which their semi-automatic action depends is the same as that of the automatic guns to be described presently. The defect in such pistols is their complicated structure. And in view of the fact that the modern double-action revolver is so simple, and rapid in its fire, it is probable that it will not be superseded for some time by the automatic type of pistol for military purposes.

THE DEVELOPMENT OF THE MAGAZINE GUN

Although every revolver, with its cylinder of reserve cartridges, is really a "magazine gun" in the strictest sense, the term as now used does not include weapons of this type. The magazines of such guns may be cylindrical in form, to be sure,

but the actual discharge of the cartridge in modern magazine guns, properly so called, takes place in the chamber of the barrel, not in the magazine as in the case of the revolver.

A practical magazine gun was not possible until the introduction of metallic cartridges, which could be manufactured in almost any desired shape. When these were invented, however, inventors were soon able to produce weapons having magazines of reserve cartridges which could be fired in rapid succession, and a number of such guns, all of them more or less practical, were invented in America and in all European countries between 1850 and 1875.

Of necessity the location of the magazine and the mechanism for automatically replacing the cartridges after discharge in such guns is confined to a few general types, any radical departure from the established shape of the gun being out of the question.

Magazines are, therefore, either in the form of a revolving cylinder, like a revolver; a magazine in the stock; a magazine placed near the lock at the breech; or a magazine in the form of a tube running along the barrel.

There are advantages and disadvantages in each of these types; and military men were still divided in opinions as to the advantage of any of these guns over a single-shot breech-loader, when in 1877 some bodies of Turkish troops, armed with Winchester repeating rifles, astonished the military men of Europe by the superiority of

these weapons. Had these military men but known it, Western American cowboys and ranchmen could have told them of the superiority of this wonderful weapon, in winning and holding a savage frontier. But it required an actual demonstration in "civilized" warfare to fix the attention of military men.

"THE WINCHESTER"

The Winchester rifle, therefore, holds the same position in the history of the development of the magazine guns that the Colt revolving pistol does in the history of revolvers. Yet, strange as it may seem, since its first practical demonstration, the Winchester has never been a popular military rifle with any important nation, including the United States. On the other hand, it has remained the most popular weapon for hunting, and for fighting savages, particular the American Indians, for a quarter of a century.

The very name "Winchester" has become a generic one, and one speaks of "a posse of men armed with Winchesters" when meaning that the guns are repeaters (perhaps of the Marlin, Colt, or Savage type), and not necessarily Winchester rifles at all.

In the history of civilized warfare, therefore, the number of Winchester rifles actually used is insignificant; but on the other hand, the rapid conquest of the Western United States,—the wresting of the soil from savage beasts and

equally savage men—is due largely to this rifle, ably assisted by the Colt revolver. The regular soldier, armed with his heavy single-shot Springfield rifle, was always an object of contempt to the frontiersmen armed with Winchesters; and while the soldier with his Springfield did the work assigned him, and did it well in the end, there can be little doubt that he was outclassed in equipment by his ranchmen neighbors, and by his savage enemies.

This being the case, one is naturally led to ask why it was that the government did not replace the Springfield rifles, on the frontier at least, by Winchesters. Certain soldiers did carry them at times, to be sure, but the guns regularly issued to the troops were Springfields. The explanation seems to lie in the fact that military authorities are guided by fixed rules, which are frequently much better in theory than in practice; and judged by these rules, the Winchester rifle never seemed able to compete successfully with the tests required by the government in competition with the Springfield.

Fastened into a vise and fired at objects to determine penetration and accuracy, or shaken up in dust boxes, and held under water until it became rusty, as is done in some government tests for guns, the Winchester was found a more delicate weapon than the Springfield—and for that matter, several others.

On the other hand, it was carried about on the dusty alkali plains, jostled about on the backs of

bronchos, exposed to all kinds of weather for years, with only the roughest care by ranchmen, cowboys, and Indians, and it still maintained its popularity in this school of rough but practical soldiery. In short, it seemed to be a good gun for anybody but soldiers, particularly those not stationed on the frontier.

It seems a peculiarly American trait to be the first to invent but the last to use improvements in military weapons.

Thus all the world was using repeating military rifles while American soldiers, still armed with archaic Springfields, were hunting savage Indians armed with Winchesters.

The American soldiers in the Spanish and Philippine Wars fought with obsolete single-shot weapons firing an obsolete type of bullet propelled by an obsolete form of powder, when even the ragged Cubans and Filipinos—strange as it may seem—had modern small-caliber magazine guns using smokeless powder.

Someone has said that the "Springfield rifle was the crime of the Spanish War"; and it is difficult to gainsay the truth of this statement. But in extenuation it may be pointed out that for a quarter of a century America has had no competitors, or probable competitors, in the war game worthy of her steel. Had she been seriously menaced by a first-rate European power, instead of savage Indians during that period, it is probable that the Springfield would have been discarded many years before it was.

The Winchester rifle used by the Turks in 1877-1878 was a lever-action gun, having a magazine for holding twelve or fifteen reserve cartridges running along the under side of the barrel—a "tube magazine," as it is called. This magazine was filled through an opening on the right side just in front of the lock, the cartridges being inserted one at a time. All that was necessary to reload the chamber of the piece from the magazine after firing was a forward and back movement of a lever held against the stock in the right hand, the backward movement also cocking the piece ready for firing. In this way the ordinary soldier could fire his fifteen shots in about twenty seconds with sufficiently accurate aim to be effective at close quarters.

THE PASSING OF THE "FORTY-FIVE"

But before the magazine type of gun had been adopted into general use as a military weapon by all nations, two great innovations in firearms had forced the recognition of their importance. These were smokeless powder and the small-caliber bullet, by the use of which the range of the rifle was enormously increased. About 1883 a Major Rubin of Switzerland discovered that by making a certain type of bullet, about .30 of an inch in diameter instead of about .45, it was possible to secure greater range, accuracy, and penetration, with less powder, lighter cartridges, and consequently less recoil.

Here were five important advantages, without a single disadvantage that could not be overcome with comparatively little difficulty.

The one important disadvantage of this new type of bullet lay in the fact that in order to secure the necessary weight the bullet had to be greatly elongated in proportion to its diameter, and this greater length necessitated a sharper pitch of the rifling in order to make it revolve with sufficient rapidity to keep it always point foremost in its flight. That is to say, the spiral rifling of the barrel had to be given a sharper turn, so that the new bullet made more turns in the same length of barrel than the old—something like twice as many. In this rapid turning, however, the soft lead bullet was found to " strip," a portion of the surface being torn off by the edges of the rifling of the barrel.

To overcome this it was necessary to make the bullet of some substance harder than lead, or at least cover it with a " jacket " of some hard substance like nickel or cupro-nickel.

This last substance, cupro-nickel, is at present the most popular one, being hard enough to take the rifling without stripping, at the same time causing the minimum of wear on the gun barrel. The wear upon the barrel is of course very much greater with such a bullet than when a soft metal bullet is used, but the disadvantage of this is entirely outweighed by the other advantages. For practical purposes, however, this wear is very slight, at least eight thousand discharges being

necessary before the accuracy of the gun is materially affected.

By the time the new bullet had been perfected, certain definite types of guns had been found best adapted for military uses. The "bolt system" of breech mechanism had been adopted universally to the exclusion of practically every other; and certain types of magazines had replaced all others. Without going into too minute details, these magazine systems fall into two classes: vertical, rotary, or horizontal magazines holding the cartridges side by side near the base of the barrel; or tubes running along beneath the barrel to a certain distance (like the sporting rifles of the Winchester, Marlin, or new Colt type) with the cartridges resting point to base. Each system has its advantages and disadvantages, as shown by the fact that both of these systems are still in use in the armies of the great powers.

But regardless of the type of magazine, all modern magazine rifles may be divided into two classes: those made with "cut-offs" and those without them. The "cut-off" is an arrangement whereby the cartridges in the magazine may be held in reserve, the weapon being used as a single breech-loader unless the occasion for very rapid firing arises. A soldier using a gun not having a cut-off cannot reserve his ammunition in the magazine when firing, but after filling the magazine with cartridges must fire them in succession until the last is discharged. In this way he might find himself, at the moment when rapid

firing was most necessary, with an empty magazine, or with only one or two cartridges.

With the cut-off system the soldier loads and fires one cartridge at a time, holding his full magazine ready for the supreme moment. Many authorities hold that in case of a surprise, or sudden rush of troops, this reserve magazine full of cartridges might determine the issue, and the cut-off system is used by such countries as Great Britain, France, and the United States. On the other hand, Japan, Germany, Russia, Italy, and Austria-Hungary do not use rifles with cut-offs.

Three different systems are in use for rapidly charging the magazine. These are by single cartridges one at a time, by "charges," or by "clips." The single-cartridge system explains itself, the magazine being filled with cartridges dropped or pushed in place one by one. In guns loaded by charges, the requisite number of cartridges for filling the magazine are held in metal or pasteboard boxes, from which the magazine can be filled by a single movement, the charger case being thrown away after loading. Guns using chargers can usually be loaded with loose cartridges if desired.

In the clip system, like the charger, the cartridges are fastened on a case or clip; but unlike the charger, the clip itself is inserted into the magazine and held there until the last cartridge is fired, and loading by clips is used largely with weapons not provided with cut-offs.

THE EVOLUTION OF THE MILITARY RIFLE

1. "Tower" English flint-lock represents musket used on both sides in American Revolution.
2. Model of 1822, U. S. Springfield—made until 1844.
3. Model of 1842, U. S. Springfield—percussion cap weapon, muzzle-loading; used first in Mexican War.
4. Model of 1861, U. S. Springfield—the familiar muzzle-loading weapon of the Civil War.
5. Model of 1873-1884, U. S. Springfield—a breech-loading arm using a cartridge.
6. Model of 1898, U. S. Springfield Krag-Jorgensen of Spanish War —breech-loading magazine gun.
7. Model of 1903-1907, U. S. Springfield—the latest word in military guns and now in use by U. S. Army and Navy.

THE NEW SPRINGFIELD RIFLE

According to the opinion of American experts the best military rifle is the new Springfield rifle adopted for the United States army in 1903.

This new rifle is thought to combine more good qualities, and fewer defects, than any other rifle now in use by any country. The Kräg-Jorgensen rifle, the small-caliber magazine gun in use by the American troops for several years, is an excellent weapon in many ways, but the new Springfield is supposed to outclass it in every particular. This new rifle represents the acme of present-day gun-making. A rifle firing bullets with accuracy further than the human eye can detect even a large target like a soldier on horseback, at a rate of twenty shots in less than sixteen seconds, as is possible with the new Springfield rifle, seems to meet almost any condition that is likely to arise even in modern warfare.

This new rifle has a range of five miles, although of course accurate shooting cannot be hoped for at such a distance. Even at one thousand yards a line of men resembles a uniform band of color, heads and legs being indistinguishable. At one thousand two hundred yards it is possible to distinguish between horsemen and footmen; but at two thousand yards a man on a horse appears like a dot.

The penetration of the bullet from the Springfield is fifty-four and seven-tenths inches of pine boards at a distance of fifty-three feet; and

seventy-two inches of pine boards at one thousand five hundred yards, the penetration being greater when fired at the longer distance. Similarly, penetration of the bullet into sand and loam at fifty feet is about six inches; at five hundred yards, thirteen and one-half inches; and at a thousand yards sixteen and one-half inches.

These seemingly paradoxical figures are explained by the fact that at close range the velocity of the bullet is so great that the bullet destroys itself before displacement of the particles allows it to pass. Bullets fired into sand at a distance of fifty feet are destroyed, although only penetrating about six inches; but on the other hand, bullets buried sixteen inches deep, fired a distance of one thousand yards, are uninjured.

From these figures of penetration it will be seen that such an object as an ordinary tree, thick enough to conceal a man's body completely, affords no adequate protection against the small-caliber bullet. On the other hand, the wounds produced by such a small rapidly moving projectile are much less cruel in nature than those of the older bullets. The pain and shock produced are much less, and the wounds yield more readily to treatment, and heal kindly, recoveries being made from a large percentage of wounds not affecting the vital organs.

The fact that the bullet passes through a part, instead of lodging in it, lessens the chance of fatal after-effects.

The course of the bullet in its flight from the

modern rifle is interesting as compared with army weapons of half a century ago. The increased speed of the bullet of course lessens the height to which it must rise to counteract the gravitation pull in going a certain distance. That is, the trajectory is flattened in proportion to the increase of velocity of the bullet. The bullet from the new Springfield, when fired five hundred yards, rises a little less than twenty-one ~~feet~~ from the ground inch at its highest point. The bullet from the smoothbore musket used in 1850 rose to a height of one hundred and twenty-nine ~~feet~~ when shooting at three hundred yards. An approximate idea of the relative speed of the two bullets can be gained from these figures.

In general principles and appearance the new Springfield resembles the better type of European military rifles. It is a " charger "-loading, " cutoff " weapon, short, compact, and comparatively light, but nevertheless without great recoil in firing. Its muzzle velocity per second is two thousand three hundred feet, as against two thousand two hundred feet of the new English rifle; two thousand two hundred of the Spanish Mauser; two thousand one hundred and forty-five of the German Mauser; and two thousand seventy-three of the French Lebel. Its penetration of fifty-four and seven-tenths inches of pine boards at fifty-three feet compares favorably with the English rifle of forty-two inches of pine at twenty-five yards; the German rifle of thirty-two inches of pine at one hundred and nine yards; the Spanish

rifle of fifty-five inches of pine at thirteen yards; and the French rifle of twenty-four inches of pine at two hundred and eighteen yards.

With such a weapon as the new Springfield rifle firing smokeless powder the soldier is able to discharge aimed shots at the rate of one every two seconds with a maximum range of five miles, and it would seem that this leaves little to be desired in rifle perfection. But even this highly perfected rifle, it is thought, may be improved upon, more particularly in the mechanism of loading.

Various governments are experimenting, therefore, with the still more rapid firing automatic rifle made on the principle of the machine gun, described in another chapter. Such guns, as a matter of fact, are already in the market as sporting weapons and are found to work with perfect satisfaction, although their mechanism is necessarily more complicated than that of the magazine guns, rendering them more liable to get out of order in active service. Furthermore, the consumption of the ammunition of these automatic guns when fired as rapidly as possible is enormous, and as keeping up the ammunition supply is one of the great problems of modern warfare, it is probable that the automatic rifle will not come into general use as the military weapon for some years, unless some new method of supplying or lightening ammunition is discovered.

The vital questions of rapidity of fire, accuracy, long range, penetration, etc., that have concerned military men for so many centuries seem now to

have been solved in such a practical manner that the attention of military experts will probably henceforth be directed into other channels of investigation. Just what these channels may be remains to be seen.

VI

TORPEDOES, MINES, AND TORPEDO BOATS

IT was the inventor of the steamboat, Robert Fulton, who first demonstrated the possibilities of using submarine torpedoes, although another American, Bushnell, had made some earlier attempts.

Fulton's first demonstration was made about 1805, two years before the completion of his practical steamboat. The type of torpedo he used, and which remained in use with certain modifications for three-quarters of a century, was not the self-propelled projectile which has since been made famous by the inventions of Howell and Whitehead, but was what is known as the "spar-and-outrigger" type, the torpedo containing the charge of explosive being attached to the end of a long spar.

To use such a torpedo it was necessary for the boat carrying it to approach within a spar's length of the vessel attacked, place the torpedo against the hull below the water-line and discharge it by some mechanical device. The difficulty of accomplishing this even at night and the danger to the attacking boat was so great, not

only from the missiles of the enemy but from the force of the explosion of its own torpedo, that only a few cases are on record of successful attacks of this nature. Perhaps the most famous of these was the sinking of the Confederate iron-clad *Albemarle* late in October of 1864 by Lieutenant Cushing.

The boat in which Lieutenant Cushing made his attack was a small steam launch. The night selected for the undertaking was a particularly dark one. Anticipating such an attack, the Confederate officer in command of the *Albemarle* had protected his vessel by booms of logs surrounding her, and fastened at a sufficient distance so that the hull could not be reached by a spar of ordinary length. As Cushing's launch approached this obstruction it was detected by the Confederates, who opened fire at once; but in the face of this Cushing was able to force his little boat over the logs, place his torpedo in position, and explode it.

The force of the explosion destroyed both the iron-clad and the launch, but Cushing escaped by diving and swimming.

This attack demonstrated conclusively the possibilities of torpedo-boat attacks under cover of darkness. And so long as smoke-producing powder remained in use there was always the possibility that a rapidly moving boat might creep sufficiently close to a battle ship under cover of smoke, even in daylight, to deliver a fatal blow with a spar-and-outrigger torpedo. Indeed, even as late as 1884, during the war between France

and China, the French succeeded in sinking the *Yang Woo* in this manner.

But the introduction of rapid-fire guns, smokeless powder, and searchlights soon after, made the effective use of this type of torpedo almost out of the question.

Attention was directed, therefore, to producing some sort of self-propelled, or " locomotive " torpedo, which could act at a distance from the point of discharge.

The result of these experiments was a torpedo which could be discharged from a shore station, or from a ship, guided by means of wires which were connected with controlling batteries. This torpedo, although fairly successful, had many defects and was open to many objections. It was extremely slow, the radius of its action very limited, and the controlling wires were likely to become entangled with friendly ships, anchor chains, or propellers.

An improvement on this type of torpedo was the self-propelled or " uncontrolled " torpedo, which was first produced in practical form by the American, Howell.

This torpedo was made in the form of a long tube fitted with a propeller and steering gear, carrying in its head, or anterior portion, a charge of explosive which detonated by contact. The motive power was afforded by clockwork machinery which, when wound up by a special machine made for the purpose, continued to rotate the propeller for several minutes, carrying the

torpedo a considerable distance before running down. By an ingenious arrangement the torpedo was kept in a straight course at a certain distance below the surface of the water so long as the propeller continued in motion.

But following closely upon the invention of the Howell torpedo was the now famous Whitehead torpedo, which resembled the Howell in many ways, but in which compressed air was used for actuating the propellers, instead of clockwork. Other improvements were made from year to year, until finally this torpedo has reached a stage of mechanical perfection by which it is self-propelled and self-guided in a manner little short of the marvelous.

A great difficulty that had to be overcome in the earlier forms of torpedo was its tendency to deflection from the desired course after leaving the discharge tube. As the torpedo was usually fired from above the surface of the water and was thus plunged into the water at an angle caused by the combined action of gravity and the ship's motion, the tendency of the torpedo was to continue in the direction of the angle at which it entered the water, which would, of course, deflect it to a great distance from the target.

After many attempts to correct this, the steering gear was arranged so as to be acted upon by a fly wheel which utilized the principle of the gyroscope.

By this arrangement the torpedo always rights itself and continues in the direction of the angle

at which it leaves the firing tube, regardless of the angle at which it enters the water.

Thus the modern torpedo is a practical engine of destruction, which travels at the rate of thirty miles an hour, and capable of striking a target at a distance of two thousand yards or even more.

Recently another improvement has been added by means of which the torpedo can be made to do more than travel in a straight line. By the addition of certain controlling devices the torpedo can be so adjusted that, after traveling a certain distance in one direction, it turns automatically and continues its course in a straight line in another direction. In short, it can literally be "fired around a corner."

By this arrangement it is not necessary to have the firing tube directed at the target, and a concealed tube entirely out of range of gunshot might discharge torpedoes with disastrous effects without being exposed. In this way it is conceivable that a torpedo boat might creep up behind a headland, or take its position in the shelter of a friendly battle ship, and, unobserved and completely out of danger, discharge its torpedoes, which, after running clear of the ship or point of land, would turn automatically and steer directly towards the target. It is conceivable that such a maneuver might be advantageous in actions between fleets in the open sea because of the danger to which battle ships were exposed if they attempted to use torpedoes fired from tubes above

the water line, the kind of tubes with which many of the older battle ships are still equipped.

The possibility of an enemy's shell exploding the torpedo in its tube before it can be fired from the battle ship, thus causing the destruction of the boat, was demonstrated in the Spanish-American War; in fact, this possibility was about the only definite demonstration of the possibilities in the use of torpedoes that was made during that war.

At the battle of Santiago, while Admiral Cervera's ships were attempting to escape through the blockading American squadron, a torpedo about to be launched from the tube of the *Alirante Oquendo* was struck by an American shell. The result was a disastrous explosion which destroyed the vessel completely. This accident demonstrated conclusively that a torpedo located in a tube above the water line on a battle ship is a menace to the ship itself during the engagement; and such tubes have been omitted in most of the recent battle ships.

For several years after the introduction of automobile torpedoes it was customary to build torpedo tubes in the bows of the battle ships, a few feet above the water line, to be used during attempts to ram an enemy; but since modern naval engagements have demonstrated the improbability of ramming tactics in the future, the bow tube has gone out of use generally. It was always objectionable because it weakened the structure of the ship at the bow, and because there was the

possibility that in ramming the torpedo in the tube might explode with an effect equally disastrous to both ships.

On most of the recently built battleships only submerged torpedo tubes are used.

When these submerged tubes were first placed at the sides of the ship, however, a difficulty was encountered in the danger of injuring the torpedo as it left the tube, the pressure of the water caused by the motion of the ship breaking or distorting it before it cleared the muzzle.

To overcome this danger an extra sheathing arrangement is now made which is run out just at the moment of firing; and this has been found to work so satisfactorily that torpedoes can be discharged with accuracy and without danger of injury, from a ship moving at the rate of fifteen or even seventeen knots an hour.

Since the invention of the automobile torpedo there has been a sufficient number of opportunities for testing them in actual warfare to have determined their value as weapons.

The first instance of their use recorded was during the Chilian Revolutionary War in 1891, when the war vessel *Blanco Escalada* was destroyed by one. Three years later the Brazilian iron-clad *Aquidaban* was sunk by a torpedo fired from a torpedo boat of about five hundred tons' displacement. In the war between China and Japan several Chinese vessels were struck and destroyed by Japanese torpedoes, but in the same war sev-

eral vessels hit by torpedoes sustained no material injury.

In the war between Russia and Japan there was such extensive use of torpedoes that their position as engines of destruction is now fairly well established.

The torpedoes in general use by the Japanese navy in this war were about twenty-two feet long, eighteen inches in diameter, and weighed in the neighborhood of two thousand pounds. Each torpedo carried about two hundred pounds of explosive, traveled at the rate of about thirty miles an hour, and had a range up to two thousand yards.

So far as is known, however, no effective work was done at this extreme range.

But at shorter ranges the torpedo has indicated its position as an effective weapon. "This weapon," says an authority on the subject recently, "for many years the subject of contempt and despised by the highest naval authorities, has suddenly become a most effective and dangerous weapon both for defense and offense. Farragut's method of treating torpedoes [i.e., disregarding them] is no longer applicable." This being the case, two results must necessarily follow—efforts will be made to make the torpedo still more effective, and equally strenuous efforts will be made to reducing its effectiveness when used by an enemy.

It is quite possible, also, that it may be employed in many ways hitherto not attempted.

"One useful field of employment of the torpedo," says Lieutenant L. H. Chandler, U.S.N., "is for the defense of harbors not suitable for mining, both from regular or improvised torpedo batteries on shore, or from submarine boats. It is well known that there are many harbors in which, owing to a great depth of water, rapid currents, or other causes of a like nature, it is almost impossible to establish a thoroughly reliable system of mines. Here we have a field where the automobile torpedo is without a rival.

"The advantages offered by this style of harbor defense in places where mines are not available, or even as an adjunct to mines, are so great that I am at a loss to understand why it has not been taken up. A more powerful torpedo could be used from permanent shore batteries than it is possible to carry aboard ship, where the confined space available for handling marks the present five-meter torpedo as about the limit in length. By increasing the dimensions of the torpedo to about double those of that now in use aboard ship, I see no reason why a range of five thousand yards, with a speed for that distance of thirty knots, should not be attained by a torpedo carrying two hundred pounds of explosive; and such a weapon should give a speed of over forty knots for one thousand yards.

"From a shore battery where range and position of the enemy can be readily determined such a weapon should be absolutely accurate and reliable.

"I believe that, in all harbor defense work, but especially in those special harbors where the use of stationary mines is beset with unusual difficulties, the use of the automobile torpedo is an absolute necessity, and one which it is very unwise to neglect in the way we are now doing. Regular shore submerged batteries, with powerful torpedoes; extemporized shore batteries, submerged or otherwise, with our service weapon; and the mobile torpedo batteries furnished by the submarine boats; taken in conjunction with such stationary mines as can be used, will beyond question form a defensive barrier that it would be madness for a hostile fleet to attempt, and the two mobile features of such a defense would also go far to keep such a fleet at a respectful distance from the harbor mouth."

To combat these weapons, or rather the vessels for carrying them, the rapid-fire gun is of ever growing importance. Indeed, the Russo-Japanese War demonstrated the necessity of providing great numbers of rapid-fire guns for coast defense. It will be recalled that at the very beginning of hostilities the Japanese torpedo boats darted into the harbor of Port Arthur and sank three Russian warships. Port Arthur's harbor was not well equipped with small rapid-fire guns that could be trained quickly on the rapidly moving torpedo craft. Had it been, possibly there might be a different story to tell of that incident of the war.

At the present time the United States is con-

gratulating itself on the possession of a new torpedo which is in some respects the most effective weapon of this type ever constructed. It is known as the Bliss-Leavitt torpedo and is supposed to have a range something like twice as great as that of the older type.

Its novel feature is the adaptation of the turbine principle to its motive power, a blast of compressed air acting on the turbine arrangement of its machinery in the same manner that the blast of steam acts in the turbine engine.

The torpedo is sixteen and three-fourths feet long, with a maximum diameter of seventeen and three-fourths inches, and weighs about one thousand two hundred and thirty pounds. It is fired from the ordinary torpedo tube—a long greased tube of peculiar shape—the initial impulse in starting being given by compressed air. The torpedo will travel one thousand two hundred yards in a minute, and has a possible range of four thousand yards at which it may be effective. This long range leads many experts to believe that the smaller guns on warships will become unpopular, since their range is scarcely more than that of the torpedo, and could not, therefore, be used to keep the torpedo boat at a safe distance.

But this has not been demonstrated in actual warfare, and it is unlikely that even this perfected weapon will revolutionize fighting methods to any great extent.

A "Flying Fish" Torpedo

Torpedo at the moment of discharge from the torpedo-tube of a modern battle ship

SUBMARINE MINES

Submarine mines are simply stationary torpedoes submerged and anchored along a ship channel, and either exploded by some electrical device from a station on shore or by contact with a passing ship.

The desirability of using such dangerous and uncertain means of protecting harbors and rivers has been the subject of discussions for almost half a century. The actual destruction of an enemy's ship by such mines has occurred rarely, and the protection afforded is considered by some authorities as not in adequate proportion to the cost and danger involved; and since the introduction of such light-draught and rapidly moving vessels as torpedo boats and destroyers belief in this method of protecting harbors has probably greatly diminished. In the Russo-Japanese War, at least one battle ship was destroyed by accidental fouling of one of its own mines, and it is known that in this war and in the Spanish-American War vessels repeatedly passed over mine fields without injury.

On the other hand, the moral effect of a mined channel is undoubtedly very great, and most commanders of battle ships would hesitate before attempting to pass through a channel strewn with mines. Moreover, the destruction of the British superdreadnought *Audacious* by a mine laid by the Germans off the coast of Ireland, which occurred October 27th, 1914, proved once for all that

mines constitute a menace that even the most powerful of battle ships cannot ignore.

The use of mines by the Confederates during the American Civil War is undoubtedly responsible for the impetus given their popularity which had decreased since the Crimean War, in which they were employed unsuccessfully by the Russians.

Several vessels were destroyed by the Confederate mines, and the mouths of several rivers and harbors successfully guarded for some time by their use alone. But the conditions presented by the Civil War were peculiar, and not likely to be duplicated. The South had no boats and no commerce; her sole aim, therefore, was to seal up her harbors against all vessels. Had she possessed a navy or a merchant marine, her mined harbors might have reacted against her, as with the Germans in a few instances during the Franco-Prussian War, where German vessels were captured outside their harbors because they did not dare seek refuge from the enemy by crossing their own mine fields.

On one point, however, there is no ground for dispute: the disastrous effect of a mine exploded in contact with the hull of a battle ship is beyond question. The only question involved is whether the protection afforded is commensurate with the danger and expense; and whether more protection could not be given if the same expenditure of money was made in providing guns and other coast defenses in place of mines.

Shortly after the American Civil War three types of mines came into use, and have remained in use until the present time, modified and improved to meet recent conditions.

The first of these are known as " observation " mines, connected by cables with an observation point on shore and fired by an observer when an enemy's vessel is over the mine, or within its destructive area. These mines cannot be fired by contact, and so may be placed in harbors where friendly vessels are passing in and out. They are of little use in foggy weather, however, and the uncertainty of firing them at the right moment, due to the misjudgment of a ship's position, lessens their value as protectors. Two mines, probably of this type, were exploded near Admiral Dewey's ships when entering Manila Bay, but the explosions were premature, and no damage was done.

The second class of mines are electro-contact mines, which may explode automatically when struck, but which are usually fired from a shore station, where they indicate automatically the contact of a passing vessel by an electric indicator. These mines are connected by cable with the shore and can be disconnected and rendered harmless without removal. They can also be tested readily from time to time—a necessary expedient in southern waters, as shown by the examination of Spanish mines about such harbors as Santiago, where seaweeds and marine growths soon rendered many of the mines worthless. Un-

like the observation mines, these mines might be used as important auxiliary harbor defenses during foggy weather.

They are fired from a station, an electric signaling device warning the operator when a vessel is in contact with one of the mines.

But by this arrangement a friendly vessel attempting to pass over the mines at night, or during a fog, might be destroyed unless the operator had been apprised of the nature of the passing craft.

The third type of mine, the "mechanical contact" mine, made to explode by contact with a vessel, is not connected with the shore in any way, and is only intended for use in harbors closed to friends and foes alike. Such mines cannot be tested in any way, are dangerous to place in position, and even more so to remove. Like all the submarine mines, they have a tendency to break loose from their anchorage, and float about, becoming thus the most dangerous type of derelicts.

It is supposed to have been mines of this type that destroyed the Russian battle ship *Petropavlovsk,* one of the Japanese battle ships, and the British superdreadnought *Audacious.*

When the channel in which the mines are to be placed is very shallow the mines may be placed along the bottom and are known as "ground mines." If the channel is deep, however, they are given sufficient buoyancy to allow them to

float above their fastenings at a certain distance below the surface of the water.

The explosive used in mines is usually gun cotton or dynamite, and the charges range from fifty to five hundred pounds—sufficient to destroy the largest ships.

Mined channels may be cleared of their explosives by what is known as countermining. This is done by exploding heavy charges of dynamite or gun cotton along the channel to be cleared, the shock of the explosion causing any mine within a certain radius to be exploded. The effective radius at which a mine may be exploded with certainty by the explosion of five hundred pounds of dynamite or gun cotton is about one hundred feet.

Thus if five-hundred-pound charges are exploded every two hundred feet along the channel a passageway two hundred feet wide can be cleared, and if carefully buoyed will admit battle ships without danger.

Special "dynamite ships" have been constructed fitted with tubes for discharging large charges of explosives, which may be used for clearing mine fields.

The United States ship *Vesuvius* was such a vessel; but although it took some part in the Spanish-American War, its value as a counterminer was not tested. The torpedoes fired by this vessel, however, were of the aërial, and not of the submarine type, and were projected from air guns specially designed for the purpose.

In this connection something should be said of the aërial torpedo guns, although their work in actual warfare has not been particularly satisfactory up to the present. Several such guns of special construction are now in place in the United States, the harbors of New York and San Francisco having them mounted as part of the harbor defenses.

AIR GUNS OR DYNAMITE GUNS

The idea of utilizing compressed air as a propellant is an old one, but has never been turned to practical account until recent years.

Experiments with this means of projecting shells was stimulated by the introduction of such powerful and sensitive explosives as dynamite, which could not be projected by ordinary powders. By using compressed air, however, such explosives might be thrown considerable distances without danger, and a practical air gun for this purpose was finally invented and perfected by Captain Zalinski of the United States army.

It is guns of this type, made as fifteen-inch built-up, smooth-bores, capable of throwing a projectile containing six hundred pounds of blasting gelatin two thousand four hundred yards, that are in place in New York and San Francisco harbors; but their value in actual warfare has never been tested.

These guns are capable of using a lighter sub-

caliber shell which can be thrown a distance of six thousand yards with great accuracy.

Smaller Zalinski guns were tried experimentally on some of the American submarine boats, but without marked success. The shells used in such guns are of peculiar structure, being made of light steel and provided with a tail or vanes for rotating. They are constructed so as to explode by contact, but they may also be timed to explode at a given distance below the surface of the water.

In the Cuban War, great air guns throwing five hundred pounds of gun cotton were tested from the *Vesuvius;* but they were chiefly efficacious in tearing great holes in the earth without inflicting conspicuous injury on the fortifications at Santiago, against which they were directed.

TORPEDO BOATS AND DESTROYERS

The modern torpedo boat is the outgrowth of the achievements of torpedoes during the American Civil War, previously referred to.

Several vessels on both sides were sunk by torpedoes carried by small boats of various types during this war, and the result was an awakened interest in such weapons, and the boats best suited for carrying them. As the automobile torpedo had not come into use, the idea embodied in the first torpedo boats was to produce small, inconspicuous vessels that could dart in under cover of darkness or smoke and explode a spar torpedo.

Such boats were constructed soon after the

close of the Civil War, the first one being the *Miranda*, built in England in 1872. But only one successful attack by this type of boat and spar torpedo is recorded, that being the sinking of the Chinese boat by the French in 1884, referred to a few pages back.

Smokeless powder and searchlights soon made attacks of this nature out of the question, but meanwhile the introduction of the automobile torpedo enabled the torpedo boat to act at longer range, and soon the thin-shelled, rapidly moving torpedo boat, of the peculiar and characteristic shape now so familiar, came into existence.

To cope with these boats, larger, faster, and more heavily armed boats were built, these being known at first as torpedo gun boats, and later as torpedo boat destroyers.

In shape, general plan, and appearance the destroyer is practically identical with the torpedo boat, the main difference being in its larger size, greater speed, and heavier guns. It carries torpedoes and may be used for attack the same as the smaller boat; in fact, the distinction between the two kinds of boats is practically unrecognized in actual usage, and it seems likely that the larger type of boat will replace the smaller one in the future.

For attacking battle ships and cruisers these boats carry torpedoes which are discharged from tubes on the decks; but for attacking or resisting boats of their own class they carry a few small rapid-fire guns, such destroyers as the United

States boat *Lawrence* having two twelve-pounders, five six-pounders, and two torpedo tubes.

Such boats have practically no protective armor, depending entirely upon their speed and small size to protect them.

Within the last few years the turbine engine has enabled some of these boats to develop a speed of about thirty-four knots, and this type of engine is likely to supplant the old reciprocating type in the near future.

Torpedo craft in general range in size from two hundred and fifty to five hundred tons' displacement, and all recent boats attain a speed of at least twenty-five knots. The destroyers, or larger types of boats, are therefore very seaworthy vessels, having a large radius of action, and as dispatch boats and scouts have been found most useful, very generally replacing the fast cruisers for this purpose in the war between Russia and Japan. From the experiences of this war it seems likely that the proportionate number of destroyers will be very generally increased in navies in the future, with a corresponding decrease in the number of small torpedo boats and possibly of fast, unprotected cruisers.

TORPEDO CRAFT LESSONS OF THE RUSSO-JAPANESE WAR

On the morning of February 9th, 1904, the expectant world received the following message from the Far East:

"About midnight the Japanese torpedo boats

delivered a sudden attack on the squadron lying in the Chinese roads at Port Arthur, the battle ships *Retvizan* and *Cesarevitch* being injured."

It was a message of the Russian Admiral Alexieff to his emperor. Later he added: "None of the three ships damaged was sunk. The *Cesarevitch* is damaged in her steering compartment, the *Retvizan* in the part containing the pumping apparatus below the water line. The damage to the *Pallada* is amidships, not far from the engines." And it gave the Russian casualties as two seamen killed, five drowned, and eight wounded.

Naturally this startling first blow of the long-expected war excited the widest comment from all over the world, both in military and civil circles; and possibly the most interesting feature of these comments was the wide divergence of opinion between military and civil writers as to what lesson of warfare had been taught by the action between battle ships on one side and torpedo boats on the other. To most civilians it seemed to demonstrate that the day of the heavy battle ship had passed; that the destroyer had made the battle ship obsolete.

But among the naval experts the opposite opinion prevailed. To them the result of the battle in the Far East justified the existence of the great battle ship.

Judged by the brief news of the result alone—three modern fighting ships put out of action, and no Japanese torpedo craft injured—it would seem

that the conclusion of the layman was better than that of the naval expert. But when all the facts connected with the case are considered, and in the light of events that followed, there is little doubt that the naval men were correct in their estimate.

For many years it has been conceded that, given a favorable opportunity to strike, a torpedo boat could sink a battle ship almost with mathematical certainty. Given a dark, calm night, with the battle ships lying at anchor, unprotected by nets, scouts, or searchlights, and allow the torpedo flotilla to approach within the easy range of six hundred yards without detection—given these unusual conditions, few people, civil or military, ever doubted that any number of battleships might be destroyed by a flotilla of torpedo craft.

Yet these conditions prevailed at Port Arthur on the night of February 8-9, and only three Russian ships were injured, and these only to such an extent as to keep them a few weeks out of commission.

The action of the Russian commander on the night of the attack was that of literally courting the destruction of his fleet. Contrary to all the tenets of modern warfare he brought his vessels to anchor in an open roadstead, and neglected even the ordinary precaution of using searchlights. Under these circumstances the Japanese torpedo boat flotilla, selecting its own time and position, crept to within six hundred yards of the

battle ships (according to the Japanese estimates) and, firing deliberately, failed to destroy a single boat.

Theoretically they should have sent every one to the bottom.

And it should not be forgotten in this connection that there are no more skillful torpedo craftsmen in the world than the Japanese. It is not surprising, therefore, that the advocates of the battle ship drew a sigh of relief when the results of this action became known. The great, seven-million-dollar, armor-clad sea-monster, with twelve-inch guns and seven hundred fighting men, had justified its existence.

About six months after this first battle another series of torpedo attacks by the Japanese on a single partially disabled battle ship still further strengthened the opinion of the naval men as to the fighting qualities of the battle ship. On June 23d the Russian battle ship *Sevastopol* was injured by the explosion of a mine. Three months later she received another injury in the same spot from another mine, the second being much more serious than the first, badly crippling her. Nevertheless on December 9th she was able to move out from Port Arthur and take refuge under Chong-ten-shan, out of range of the Japanese shore guns. Her rapid-fire guns were removed, all of her crew but a hundred men were sent ashore, and she was practically abandoned, although surrounded by torpedo nets.

In this position, crippled, and all but helpless,

she was attacked by the Japanese destroyers on December 9th, 13th, 14th, 15th, and 16th, these vessels steaming past her at a range of one thousand two hundred yards, discharging a great number of torpedoes, many of which exploded in the nets, but none of which injured her.

Finally, during a blinding snowstorm, one torpedo got home and exploded, injuring but not disabling the already crippled fighter.

All this, of course, seems unfavorable to the torpedo boat. But this is by no means the same as saying that this type of fighting craft is a failure. Indeed, the results were just about what the majority of naval observers had predicted that they would be.

But the work of the torpedo boats at the battle of the Sea of Japan a few months later showed that for certain well-defined purposes these boats have their place in modern warfare. That place, however, as all naval men knew, is not in the line of fire among battle ships in a daylight battle, such as that in the Sea of Japan. But in the darkness of the night following the battle, when the battered fighters of Russia, crippled and exhausted with hours of fighting, huddled together and attempted to find some rest or some avenue of escape—then it was that the torpedo boat demonstrated its possibilities.

Swarming around the doomed vessels, rushing boldly upon them until the range was so short that there was no chance of missing the mark, the Japanese torpedo boat flotilla continued the

work that the battle ships had begun so well in daylight, and before morning sent six of the enemy's fighting ships to the bottom.

Here at last was the really important field of action for the torpedo boat and the destroyer—to give the death stroke to a crippled but still dangerous enemy. And at this particular work they proved themselves ideal vessels.

Coming fresh into the fight, against opponents exhausted, half blinded, with many small guns disabled, and searchlights shot away in some instances, the torpedo boats were able to rush in so close that they were completely out of reach of the heavy turret guns, which could not be depressed sufficiently to be effective. Here, even with the searchlights upon them, and the smaller guns hammering them, so close that the Russians could see the men moving coolly about their work, they fired their torpedoes, sinking ship after ship. In return some of their own frail boats were disabled and sunk, but the work they completed offset their loss a hundredfold.

And if the prestige of the torpedo boat was waning before that eventful night's work, by the following day it was as bright as ever.

The torpedo boat is to the navy, then, what the cavalry is to the army. It cannot stand the brunt of battle, cannot hope to attack a well-arranged line of battle ships, even in the night, under ordinary circumstances. But for getting home the death stroke when the enemy is demoralized, there is nothing as yet to compare with these frail

vessels. They are essentially close-quarter fighters—the dagger or mace, only to be used when the lance and sword are no longer available—but like these minor weapons of the knight, they are quite as indispensable to a fighting equipment.

It is not unlikely, however, that a torpedo boat of an altogether novel type will play an important part in warfares of the future. Justification of this expectation is found in the remarkable work accomplished recently by Mr. John Hays Hammond, Jr., in the development of an apparatus for controlling the direction of a boat by means of wireless impulses sent from the shore.

Mr. Hammond's experimental boat, called the *Natalia,* has demonstrated the feasibility of his system, being sent hither and thither at the will of the operator, having no person on board and being solely under radio-control.

It is obvious that a spar torpedo attached to such a craft would render the vessel a torpedo boat of a novel and peculiarly dangerous type. Moreover, Mr. Hammond is said to have applied his mechanism of radio-control directly to the torpedo itself, demonstrating that the only limit to the effective control of such a torpedo is the limit of vision as aided by the telescope. So even at its present stage of development the radio-controlled torpedo appears to furnish a new means of coast defense of great value. Its limitations can be determined only by tests in actual warfare.

VII

MODERN BREECH-LOADING CANNON

IT will be recalled that after the first introduction of breech-loading cannon they were for a time replaced by muzzle-loaders, owing to the imperfections in the breech mechanism which made them dangerous to use, at the same time giving little advantage over muzzle-loading guns in the time required for loading. But when the disaster to the muzzle-loading gun occurred to the war vessel *Thunderer,* showing that even more serious accidents might occur with muzzle-loading guns than with breech-loaders, the attention of the military and naval men was again directed to the breech-loader.

The danger in using the first breech-loaders lay particularly in the possibility of premature firing of the piece before the breech was completely closed.

This difficulty was easily overcome by a simple device whereby it was impossible to fire the gun until the breech was locked. About the same time, great improvements were made in the breech mechanism itself, so that it could be opened much more easily than in the first breech-loading guns.

In those first guns the breech piece consisted of

Eighteenth Century Cannon

Cannon in front yard, Washington Headquarters, presented by the Navy Department of the U. S. It bears the arms of Great Britain, and initials "G. R.," showing that it was once the property of King George III.

a solid piece of metal, fitted with threads and screwed into place after the manner of the common screw. This consumed much time both in opening and closing the breech, as the screw was necessarily a long one, requiring a number of turns either to remove or replace it.

To overcome this defect several types of breech blocks were invented, the Germans for a time favoring what is known as the wedge, or block system, while the French were experimenting with what came to be known as the "interrupted screw" system.

Both of these systems, greatly modified, are still in use with certain classes of guns, but in the heavier ordnance the interrupted screw has now come into general use to the exclusion of the other system.

In the interrupted screw system the breech block is made with a screw thread of the requisite length, and the breech of the gun into which it is to fit is made with a similar female screw to receive it. But instead of the continuous line of screw threads the block is divided into six equal parts and in each alternate part the screw thread is entirely removed.

In the corresponding alternate parts of the breech of the gun the screw threads are also planed away so that the breech block may be pushed into place without any turning motion and fastened there by a one-sixth turn.

By this arrangement the breech block is of course weakened by one-half, but this defect is

easily remedied by doubling the length of the screw.

In this way the breech-loading process was greatly facilitated, breech blocks of any size or length being opened simply by a one-third, quarter, or sixth turn, whereas the same sized block made with a continuous screw would require ten or twelve complete turns.

This improvement alone would have insured the adoption of the breech-loader; but another factor introduced at about the same time as the improved breech block also aided in determining it. This was the introduction of slow-burning powder.

With quick-burning powder, the force of the explosion is exerted chiefly at the base of the gun, and for using such powder weapons of great thickness at the base (though perhaps very thin at the muzzle) were necessary, as the force of the explosion was expended within a comparatively few inches of the breech. With slow-burning powder, however, this force could be distributed more uniformly along the barrel; and as the pressure was more uniformly exerted along the entire length of the barrel it became necessary to strengthen the muzzle by thickening it, while a corresponding decrease in thickness towards the breech was possible.

The length of the gun was also increased, the greater length up to a certain point giving great velocity.

With such greatly lengthened cannon, muzzle loading was out of the question, as the space re-

quired for running in the gun, manipulating the rammer, etc., was not available, particularly on shipboard, where space is always at a premium.

Shortly after this improvement in breech mechanism there was also an improvement in the form of ammunition used. This was the introduction of metallic cartridge cases—practically enlarged forms of the ordinary rifle cartridge case, at least for the smaller caliber guns. Such cartridges served the double purpose of facilitating loading and controlling the escape of gas. In the early type of breech-loader, before the introduction of the metallic cartridge cases, a great difficulty was encountered in making the breech absolutely air tight. To overcome this difficulty some sort of obturator was necessary, frequently a peculiarly shaped pad of asbestos.

But the metallic cartridge case did away with this device, the rim of the cartridge case serving the same purpose even better than the specially designed obturator.

With the introduction of ammunition fixed in metallic cartridges, quick-firing guns became possible, such guns holding the same relative position to ordinary cannon that the breech-loading rifle does to the ordinary musket. For the lighter type of cannon the cartridges used are closely similar to the ordinary rifle or revolver cartridge, in the principles of construction as well as in appearance, the projection, powder, and percussion cap all being fixed in a single piece.

With the heavier type of ordnance, however,

there are certain disadvantages in the use of such cartridges if made in a single piece.

Thus if such cartridges were made with the projectile fastened to the cartridge case, it would be necessary to make this case of great thickness and strength; and the entire weight would be so great that manipulating without the aid of machinery would become impossible. By actual experience it has been demonstrated that such heavy pieces of ordnance may be loaded and fired quite as rapidly if the projectile and the cartridge cases are made in separate pieces, as they are then sufficiently light so that the men about the gun can handle them quickly.

Another disadvantage of having such large projectiles fixed in metallic cases with percussion explosives in place is the constant danger of accidental explosion.

It is customary, therefore, with cartridge cases of larger projectiles, not to have the percussion cap attached. As a matter of fact, in most of the modern types of guns, the electric fuse has replaced the percussion cap for heavy ordnance. But such guns are usually made so as to use either the electric or the percussion system, changing from one to the other without any loss of time. In such cases the percussion fuse would ordinarily not be used unless the electrical firing device were shot away or became accidentally inoperable.

Constant improvement and simplification of the breech-block mechanism has been made, until fin-

ally the process of opening and closing the largest type of gun is done by a few simple motions of one man, unaided by machinery. With everything but the heavier natures of ordnance, and in these also in some cases, opening the breech and partially extracting the cartridge case is now performed by the single continuous movement of a lever. With this perfected breech mechanism a quick-firing gun, even of six inches caliber, using metallic cartridge cases, can shoot several more shots per minute than the ordinary breech-loader, and the lighter type of quick-firing guns are of course proportionately quicker.

It should not be understood, however, that the method of loading by metallic cartridge cases has entirely replaced the older method of inserting the propellant in specially prepared silk or canvas bags. There is a certain disadvantage in the use of ponderous metallic cases for the heavier guns which has not sufficient compensating advantages to make their use imperative. There is a danger in using explosives in silk bags, however, which is entirely obviated by metallic cases. The danger lies in the fact that certain particles of the burning silk bag are likely to be left in the gun after each discharge.

This would, of course, cause premature discharges with disastrous results, if not detected before the charge was inserted.

To make sure, therefore, that no sparks remain in the gun, the breech must be thoroughly washed out after each discharge. This is, of course, very

inconvenient and consumes precious time, and it may be taken for granted that eventually metallic cartridge cases in some form or other will replace cloth bags in the heavier types of ordnance, just as metallic cartridges have replaced all other forms of ammunition in the lighter cannon and in rifles and revolvers.

QUICK-FIRING GUNS

With naval guns there are two classes of quick-firers, heavy and light.

Roughly speaking these differ from each other in breech mechanism, method of firing, and kinds of ammunition used, although some of the twelve-pounders, while classed as "light quick-firers," resemble more nearly the heavy quick-firers in mechanism. No two navies of the world correspond exactly in the sizes of the calibers of the guns, but generally speaking the heavy quick-firing guns range in caliber from four-inch to six-inch guns, although some of the very recent eight-inch and even nine-inch guns are classed as rapid-firers. The light rapid-fire guns range from the twelve-pounders to the one-pounders, the three- and six-pounders being perhaps the most popular.

The six-pounders and all smaller guns are trained and fired by the gunner with a shoulder piece like a gun stock.

The six-inch quick-firer may be taken as the best representative of the heavy rapid-fire class of guns. Its normal rate of fire is about four shots

per minute, as against the older breech-loading six-inch gun's four shots in three minutes, the metallic cartridge accounting principally for this difference.

The electric primer is also a distinct time-saver over the tube system in use with the ordinary six-inch guns, as the piece is ready for firing the moment the breech is closed when this primer is used, whereas the tube cannot be inserted until afterwards in the older guns.

There are practically no disadvantages in the quick-firing gun in comparison with the older type, and the new guns of six-inch caliber or less are all made as quick-firers, and many of the older type of guns have been, and are being, converted into quick-firers.

There is also a difference of opinion among ordnance experts as to the type of guns adapted to the "fixed ammunition"—that is, ammunition in which the shell and projectile form one piece, as in the ordinary rifle cartridge.

In the British navy, for example, practically all ammunition larger than that for the six-pounders is of the "separate loading" type, the cartridge case containing the charge and the projectile being separate. In other navies, however, much larger guns are loaded with projectiles and cartridge cases made in one piece, and there is no question that some speed in firing is gained by this arrangement.

When such cartridges are made with electric fuses the danger of accidental explosion is mini-

mized, and as this is apparently the principal reason for the British Admiralty's not adopting such cartridges, it seems that they are lagging behind some of the other powers in this respect. As a matter of fact, if an accidental explosion were to occur in a closely packed magazine the destructive effects would be so great that a few extra hundredweight of exploding shells and cartridges would make no practical difference in the result.

LIGHT QUICK-FIRING GUNS

The perfection of the torpedo and torpedo boats made necessary the type of small cannon known as quick-fire or rapid-fire guns.

As we have seen, the torpedo may be successfully launched at a distance of at least one thousand yards, and possibly twice that distance, with fair chance of success. It is necessary to destroy or disable the torpedo boat, therefore, before it has approached within that distance, and for repelling such attacks the light rapid-fire guns are practically adapted. For the approach of the best type of torpedo boat or destroyer can be made so rapidly, that to cover the distance from a point out of ordinary range of the one-, three,- or six-pounders, to within torpedo range, only requires from one to three minutes.

During this interval of time, therefore, the rapid-fire guns must do their work.

And as the target presented is a small and

Loading a Fourteen-inch Cannon of the Type Used at the Panama Canal
(Note the "interrupted-screw" breech block)

rapidly moving one, every possible means is taken to make these little guns rapid and accurate. That this has been accomplished is shown by the fact that as high as thirty shots a minute can be fired with these guns, and as many as twelve hits out of fifteen scored. There are, indeed, automatic guns of the same calibers that shoot even faster than this, but these will be considered in another section, and they should not be confused with the guns described here.

The quick-firing guns are usually mounted so that the gunner, standing with the shoulder pad against his left shoulder and grasping the trigger with his right hand, can turn the gun about freely, elevating or depressing it, or training it to right or left at will, always keeping his eyes on the target. The breech-block system does not resemble that of the heavier type of guns, but in place of the interrupted screw mechanism it has a "falling block," or some similar system, worked by a lever and resembling the falling-block arrangement of the ordinary sporting rifle.

A single movement of a lever opens the breech and ejects the empty shell, and a reverse movement of this lever closes the breech and cocks the piece ready for firing.

As the gunner does not remove his eye from the sight in firing, great accuracy in shooting is possible, and handling such a gun becomes very much like using the ordinary sporting rifle held in a rest.

It is on guns of this type, and machine guns,

that battleships must depend for warding off torpedo boats, and for this reason every available space on the modern war vessel, from deck to fighting top, is utilized for mounting them. But the ordinary type of small caliber machine gun, such as the Maxim or Colt, is no longer considered formidable enough to cope with the large type of destroyer now replacing the earlier and smaller torpedo vessels.

This principle of automatic action, however, is now applied to heavier guns, which will be referred to again at length in another place.

HEAVY MODERN ORDNANCE

In determining the best type of heavy cannon, each country has its own idea as to what sizes and weights best fulfil the conditions to be expected in warfare.

It is obvious that heavier guns may be used in land batteries than on shipboard; while, on the other hand, the battle ship is able to use heavier guns than could ordinarily be employed for siege purposes or by armies. But after taking into account all probable conditions likely to be encountered, certain sizes of heavy guns have come to be generally recognized by most nations as fulfilling all requirements.

The twelve-inch gun, for example, had gradually come to be considered as the ideal heavy gun for battle ships until the coming of the superdreadnought.

Of course, the ideal gun, everything else being equal, will be the lightest one, not only on account of the rapidity of fire possible with the smaller guns, but also on account of the space occupied by ammunition and the extra cost of the projectile and powder. The question of the saving space is not usually a vital one with stationary land batteries, to be sure; but aside from this, most of the other conditions must be considered equally in the making of weapons to be used on land as well as on the sea.

There are, to be sure, certain monstrous guns mounted for coast defense work which are altogether too large and unwieldy to be used on shipboard. Such a gun was the one exhibited at the World's Fair in St. Louis with a bore sixteen inches in diameter, firing a shell some twenty miles, and costing in the neighborhood of one thousand dollars for each round fired. Similar guns are still made and are in service not only in the United States but in certain foreign countries. Their possibilities of destructive action have been demonstrated in the case of the German siege guns (said to be of forty-two-centimeter caliber) transported by automobiles and used against the Belgian and French fortifications in the early autumn of 1914.

Some of the older battle ships still carry guns whose caliber is as great as the gun exhibited in St. Louis; but such guns are simply hold-over weapons of a past epoch in gunmaking. Even thirteen-inch guns, such as are used on the Amer-

ican battle ships *Oregon* and *Massachusetts,* are no longer made.

On the other hand, the newest superdreadnoughts, including the *New York* and the *Texas,* are equipped with fourteen-inch guns.

All guns at the present time are of the built-up type, but in place of the heavy forged jackets in use for so many years some nations are now using guns built up of successive layers of steel wire, these layers being protected by one or more jackets of solid metal. Such guns have proved superior in many ways to the older type of guns. The principle of the wire-wound gun is an old one and has been in use for many years in the manufacture of the barrels of sporting pieces.

It will be recalled also that the leather cannon of Gustavus Adolphus were " wound " guns, although the material he used was leather or rope and not steel wire.

Some idea of the revolutionary changes that have taken place in heavy guns used in naval warfare may be gained from comparison of the best type of gun used at the close of the American Civil War with the corresponding heavy gun in use to-day. This comparison is fairly indicative of the actual progress made, as the American navy at the close of the Civil War was the largest navy in existence, and its ordnance was unsurpassed by that of any foreign power.

The heaviest piece of ordnance in the 1865 war was the fifteen-inch muzzle-loading smooth-bore; while to-day this piece is represented by the

twelve-inch breech-loading rifle. This fifteen-inch gun weighed about forty-two thousand pounds as against one hundred and ten thousand pounds of the modern rifle. The thickness of these two guns at the breech is about the same, but the modern gun is almost three and one-half times as long. The maximum charge of the smooth-bore was one hundred pounds of powder, which shot a projectile weighing four hundred and fifty pounds. The charge of explosive for the twelve-inch gun is three hundred and sixty pounds of smokeless powder, and its shell weighs about eight hundred and fifty pounds.

The muzzle energy of the fifteen-inch smooth-bore was slightly less than eight thousand foot-tons, while that of the twelve-inch rifle is something over forty-six thousand foot-tons.

The most striking thing in this comparison is the respective number of shots that each gun was capable of firing before becoming useless or dangerous. The number of full charges that could be fired by the fifteen-inch smooth-bore was limited to twenty; while that of the twelve-inch gun, using nitro-cellulose powder, is about five hundred.

BUILT-UP AND WIRE-BOUND GUNS

As we have seen, the strain put upon cannon by modern explosives makes it necessary to strengthen them in an unusual manner.

A gun that is cast in one piece, as the cannon

of a hundred years ago were made, would be shattered by the first discharge.

It is customary, therefore, to strengthen the guns, either by shrinking on successive jackets of steel, which are kept in a state of tension all the time so that every particle of the gun receives the shock of the detonation at the same time and so divides it equally; or by winding on successive layers of steel wire, which have the same effect as the steel jackets. Indeed, it seems certain that wire-wound guns are superior to the jacket guns; and as these are likely to be the popular form of cannon for some time to come at least, a somewhat fuller description of them may be of interest.

The modern wire-wound gun is the outcome of the efforts of the English civil engineer, J. A. Longridge, begun more than half a century ago. His attention was called to the subject during the Crimean War by the frequent failure of the guns then in use.

"After much consideration," he wrote, "I came to the conclusion that the best method of constructing a cylinder to resist internal pressure was to take a comparatively thin tube and put upon it successive coils of wire, each coil being laid on with a definite tension, varying according to some law, which would be expressed by a function of the radial distances of such coil from the axis of the cylinder. In this way, provided each initial tension of laying on were properly calculated, the completed cylinder would be in a state

of varied initial stress, and when such stress was supplemented by the stress arising from the internal pressure due to the explosion of the powder, the stress under fire would be uniform throughout the whole thickness of the cylinder. To determine the proper tension of laying on to fulfil these conditions was a mathematical problem of some complexity, but it was solved and embodied in a formula which is still in use. This invention was the subject of my first paper, dated May 24, 1855."

So confident was Longridge of the advantages of his gun that he constructed one on the lines outlined above, and offered it free of cost to the British government; but because of prejudice and ignorance of some of the officials, it was not accepted. And it was not until twenty-five years later, when Armstrong began experimenting with wire-wound guns, that it dawned upon military authorities that they had retarded gun construction a full quarter of a century.

In the meantime three American inventors had become interested in wire-wound guns, Woodbridge, Crozier, and Brown. Indeed, Woodbridge had made a wire-wound gun some five years earlier than Longridge, in England. But this first gun was a failure, owing to some mechanical defects, and it was not until after the experiments of Armstrong that any great progress was made in this country. Later, Woodbridge made several other wire-wound guns of improved patterns, and Crozier's guns proved to be serviceable weapons;

but in many ways the guns of Mr. Brown, which have been improved year by year, are perhaps the most remarkable guns of American manufacture.

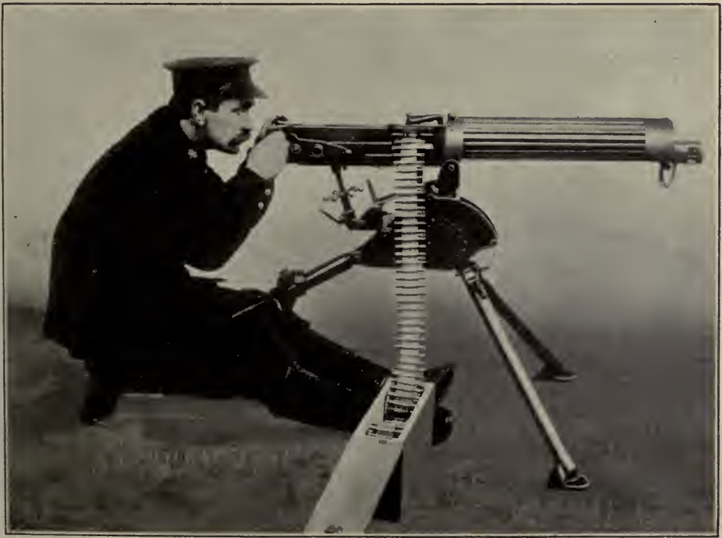
In the manufacture of the Brown gun the internal compression tube is built up of a number of longitudinal steel bars or staves, wrapped together under the tension of steel wire. In this manner a highly elastic tube is possible, which has proved advantageous in actual tests as well as theoretically. The advantages as summarized by a naval expert are as follows:

1. In consequence of the small weight of each of the component parts of the gun, crucible steel can be used economically. 2. The small size of the segments and the ingot from which they are rolled admit of their being carefully cast and uniformly forged, so as to insure uniformity of metal, and of their being thoroughly annealed. 3. As they can be readily rolled into shape, the method of construction is exceedingly economical. 4. They can be thoroughly and conveniently inspected. 5. The size and thinness of each segment insure a thorough and uniform tempering and annealing, if temper be considered desirable. 6. The size of the segments admits of readily setting up conditions of special elasticity by cold work.

These advantages, while possibly not appealing to anyone but the expert as being of great importance, are really so, as is shown by the performances of the finished gun. But one fact is apparent to anyone—the modern high-power gun is a

The European War

British, with machine guns, take up a position in a ditch, in France.



Lewis Machine Gun

With this gun the Belgians checked the advance of the Germans through their territory.

complicated affair, the solid-appearing, finished product giving no hint of the numerous pieces and layers of metal squeezed into its steel jacket.

In the beginning of the process of manufacture the bars for the core of the gun are assembled and clamped together in a manner not unlike that of a cooper assembling barrel staves and held with temporary hoops.

The core so made is then placed in a lathe, the two ends machined, and the breech and muzzle nuts are shrunk on.

The gun is then turned down to the proper size in the lathe, and the process of winding begun.

The wire used is of specially tempered steel, and is not made in the shape of ordinary wire, but is rectangular in section, so that in winding there is no loss of space, as there would be if wire of the ordinary shape were used.

When the winding is finished the gun is bored out, a steel jacket shrunk on over the wire, and a thin steel tube, or "liner," inserted in the bore. The weapon is then ready for finishing with breech piece and mountings. It will be understood that this winding process is a most delicate and important one. Special machinery is used to keep the wire at a proper tension, at the same time winding it on evenly, as the strength and value of the weapon, when completed, will, for reasons just given, depend upon the tension of the wire windings.

MACHINE GUNS

The term " machine gun " has come to be applied to the type of rapid-fire small-caliber rifle which, when once started, continues to fire four hundred to seven hundred shots a minute, the entire process being automatic, part of the energy of the explosion of the cartridge being utilized to recharge and discharge the piece.

Such guns are of very recent origin, the first attempts approaching success with such a weapon being in 1870-71, when the French made use of a multiple-barreled gun called a *mitrailleuse*. In actual practice this gun was not very successful. It was made of some twenty-five or more rifle barrels mounted in parallel round an axis, with a breech mechanism by which all the barrels could be loaded and discharged at once.

In this way a shower of bullets could be thrown at one discharge.

But unfortunately these bullets as fired struck all together in practically the same spot at close range. So that while the number of aimed bullets discharged at a single discharge almost equaled the volley of an entire company of infantry, the space covered by the bullets so fired was scarcely more than that covered by two or three men. For this reason the mitrailleuse was wasteful of ammunition, besides being awkward and slow to load, and having a recoil sufficient to necessitate reaiming before every discharge.

The first really successful machine gun, which

was semi-automatic in action, was the invention of Dr. R. J. Gatling, of the United States, with which five hundred shots per minute could be fired in succession by simply turning a crank at the base of the gun.

These shots, fired in succession, were not confined to a given space, but could be scattered broadcast at any angle, horizontal or vertical. The superiority of such a weapon over the French mitrailleuse was so evident that it was speedily adopted into all leading armies of the world.

The Gatling gun is constructed of ten ordinary rifle barrels arranged cylindrically to revolve about a central axis. Only a single barrel is discharged at a time, the other nine being necessary to the mechanism of loading and unloading. In this way a rapid succession of shots is possible; although the actual number fired by each barrel is only one in ten. In this way overheating is avoided more readily than is possible if the shots are fired from a single barrel.

Cartridges are supplied to the barrels through a hopper placed at the base of the gun, the cartridges dropping one at a time through a slot made for the purpose. A drum containing the cartridges is placed over the hopper, and this supplies them to the barrels, the rate of discharge being regulated by the rate at which the firing handle is turned.

Absolutely accurate aim is somewhat interfered with by the necessary vibration of the crank movement and the recoil; but at the ordinary

range the aim can be made sufficiently accurate to make the Gatling gun a most deadly weapon. Closely packed lines of men advancing in close order after the manner of half a century ago would be completely wiped out in a few seconds at ordinary musket range by a single Gatling or automatic gun.

What can be done with such weapons against masses of men was demonstrated by Lord Kitchener in the battle of Omdurman, when the dervishes lost over ten thousand killed and fifteen thousand wounded and taken prisoners, in attempting to rush the inferior British forces armed with artillery, automatic guns, and repeating rifles. The British casualties were less than five hundred, all told.

Shortly after the perfection of the Gatling gun, experimental patterns of which have been made to fire nearly one thousand shots per minute, another machine gun, known as the Gardner gun, came into use. This gun was quickly superseded, however, by a somewhat similar gun called the Nordenfelt gun, which was worked with a crank in much the same way as the Gatling gun, but in which the barrels were placed horizontally instead of spirally.

This gun was thought to be better adapted to use on shipboard, but it never gained the universal popularity of the Gatling.

Meanwhile attempts were being made to make an actually automatic gun—one in which the energy of the propellant could be used instead of

the crank, as in the Gatling and Nordenfelt guns.

As early as 1884 Hiram Maxim had taken out patents for such a gun, and by 1889 he had so perfected it that it was adopted into the British army. In this wonderful gun, and guns of its type, the loading, firing, extracting, and ejecting are all performed by the gun itself after the initial shot is fired, so that once the gun is started firing it will continue at the rate of six hundred or more shots per minute without human aid or assistance.

The Maxim has but a single barrel, the breech mechanism of which is actuated by the force of the recoil. It is thus a most striking example of utilizing energy that would otherwise be wasted, without impairing the energy imparted to the bullet.

The cartridges are supplied to the gun on a specially constructed belt, which runs transversely through the base of the gun.

The recoil of the first cartridge discharged puts in motion the machinery which ejects the empty shell, reloads the chamber of the barrel, and fires the cartridge, repeating this seemingly complicated process at the rate of six hundred shots per minute.

In another type of automatic gun which acts equally well, the force of a small portion of the gas of the cartridge itself is utilized, in place of the recoil, for manipulating the automatic mechanism. The Hotchkiss gun and the Colt gun act on this principle.

In these guns there is a minute vent hole in the barrel near the muzzle of the gun, this vent communicating with a tube leading to the machinery in the breech of the gun. When the bullet has passed this minute hole in the barrel, gas escapes into the tube below with enough force to set in motion the mechanism which ejects the empty shell, reloads, and again discharges the piece; and this is repeated until the ammunition is exhausted, or until the operator wishes to cease firing.

Although differing from the Maxim in principle and detail, in rate of fire and reliability, the Hotchkiss and the Colt guns are probably not inferior. On this subject experts do not agree, the English preferring the Maxim, the French the Hotchkiss, and the Americans the Colt guns.

The great defect of all automatic guns is the rapid heating of the barrel.

The Maxim gun is fitted with a water jacket to obviate this, and where a supply of water is plentiful this works very satisfactorily. The rate at which the barrel is heated, however, is shown by the fact that seven and one-half pints of water in the jacket are heated to boiling point by a minute and a half of firing. To keep such a gun continuously in action for any length of time, therefore, is a serious problem, particularly in open field operations where water is scarce.

The water jacket is not used in the Hotchkiss or Colt guns. In place of this the Hotchkiss has a so-called " radiator " on the barrel—a series of ridges affording an increased surface to the air.

The Colt gun is provided with a very heavy barrel to meet the condition of overheating; and besides this, a puff of air is driven through the barrel automatically after each discharge, thus cleaning and cooling it slightly.

Another great problem in using machine guns in the field is that of ammunition supply. Such guns are extremely wasteful, a target when hit being usually riddled with a number of bullets where one would suffice. But in this respect they are no different from the Gatling or the Nordenfelt guns, and the absence of the crank movement makes more accurate aim and better shooting possible.

All of the types of automatic guns just described have been tested in actual warfare and found satisfactory; but the Colt gun has a slight advantage of greater portability, being somewhat lighter than either of the other two.

When the practicality of these automatic guns of small caliber is considered, it is only natural to wonder why something on the same principle could not be applied to guns of much larger caliber. Why would it not be possible, for example, to make one-pounders, three, six, and even larger guns on the principle of the machine gun, since the ammunition they use is practically the same in all essentials?

This question has been answered in the affirmative by the gunmakers, as proved by the "pom-pom" of Boer War fame and other large-caliber automatic guns now in use.

It was in the Boer War that the possibilities of

the pom-pom were first made evident, although Sir Hiram Maxim, the inventor, had tried in vain to interest British military authorities in this weapon. There is little doubt that many of the officers of the British force when the Boer War started had never more than vaguely heard of the pom-pom. But when these terribly destructive weapons, manned by a handful of men, began pouring British-made one-pound shells into the British ranks at the rate of some three hundred a minute it was realized that someone in authority had been caught napping, or had erred in judgment.

A little later, Sir Hiram Maxim, in addressing some remarks to a body of military men who were discussing the possibilities of the machine gun, gave the following story of the development of the pom-pom, how it came to be invented, and why the English army did not adopt it.

"If the British government did not know about the pom-pom," said Sir Hiram, "it was not my fault, for there is no man who ever appreciated the value of that arm more than I did, and no man who tried harder to get it into the service; but it was always with the same fate. It was said that the gun is unnecessarily large to kill a man, and is altogether too small to be considered a piece of artillery; therefore, there was no room for the pom-pom, or the 37-mm. gun, as we call it, in any branch of His Majesty's service.

"Well, they said, suppose you have some of these guns; why, a single piece of artillery will

put a whole battery of them out of action in five minutes.

"But what happened? The Boers wanted some, and the directors of the firm sent the late Admiral Commeral round to the War Office, asking whether they objected to their selling their guns to some other nation. They said they had not the least objection. What happened in the end? We found that instead of a single piece of artillery putting a battery of these guns out of action in a few minutes, that three Boers with one of them put a battery of English field guns out of action. That is what took place.

"The history of this pom-pom has never been told. When I went into the machine-gun business I was simply an engineer and electrician; but I had learned my trade fairly well. I made a gun and took it down to Hythe to fire in the presence of Lord Wolseley. The authorities there had never seen such a gun before. Usually the guns jammed; they could not fire them at all. I remember that there was a lecture about machine guns, and so much said about their jamming and getting out of action that the general opinion seemed to be that they were useless.

"When Lord Wolseley saw this first gun fired at a target 600 yards away, which was made of cast iron, and when we ceased firing we heard forty shots strike the target after we stopped, it was very impressive. There were a lot of bullets in the air and a lot of sound waves coming back, and we heard those after the gun stopped firing.

I had the honor of a seat at the right hand of his lordship, and we discussed machine guns, and some of the officers joined us while they were smoking. And they asked me if I could make a machine gun which would have a range a good deal longer than the present one, that would penetrate a torpedo boat, that the ammunition should not be too dear, and which would be quite as effective as a small gun for meeting a crowd of savages as swords.

" After studying the subject a long time I began. We had a large powder chamber, a three-quarter-inch bore, a projectile the shape of those used in military rifles, but the bullet had a steel core in it, and was made in segments, and the sectors of this were made by the envelope of lead or tin. It was strong enough to hold a bullet together in flight, but if you wanted it to scatter you could move a little lever, which brought three or four points of steel in front of the middle and scratched the envelope, and gave a scattering result, like grape and canister at short range. That seemed to meet every requirement.

" But the question came as to whether it would not be considered an explosive bullet, because it all went to pieces.

" So I changed it so that the projectile weighed over one pound—and that was the pom-pom; and that is how the pom-pom happened to be made. That particular form of gun was very much enlarged. The first one used ammunition the same as the Hotchkiss, and afterwards they were made

considerably larger for the U. S. Government, and still larger for the English. So that the pom-pom at the present moment is rather a powerful arm, considerably longer than at first. It first fired 400 rounds a minute, but I have reduced the speed down to 300."

Upon the same occasion Sir Hiram gave his views about the relative merits of the different systems of automatic guns—the recoil *versus* the escaping gas system. In speaking of his early efforts and experiments he said: "I thought it was better to stick to the recoil system, and not gas-operated guns, although I brought them out at the same time. There are many advantages connected with that system also; but I think as good an illustration as we can have is that the Americans have always looked upon the Maxim gun as having been invented and brought out in England, and as being an English gun, although I am an American myself. But in the end, although they favored the Colt gun as being American, they were obliged to give it up, and now Colt's people are making a Maxim gun worked with a recoil, and paying us a royalty at the present moment. So that is a pretty good indication that those which work with a recoil are better than those which work with gas coming out at the sides of the barrel."

As regards the possibility of making automatic or semi-automatic guns of heavier caliber than the pom-pom, there is no longer any question. Such guns are now made, and are being tested by all the

military nations of the world, although details as to the work are not always forthcoming.

Naturally Maxim is in the van of inventors in this field. He has found no difficulty in putting out a nine-pounder gun, practically automatic in action, which fires sixty shots a minute. The nine-pounder shell with its cartridge is about a yard in length; and this gives some idea of the amount of energy that must be utilized to handle such shells at such a rate of speed.

One can scarcely conceive a weapon more terrible than one that can almost literally pour these huge projectiles upon an enemy.

Once the range is found it would seem to the layman that they would be absolutely annihilative.

But there are two vital defects in such a showering of ammunition—the shots cannot be well aimed, and there is likely to be too great a consumption of ammunition, which, as has been pointed out, is the bane of the artilleryman's life to-day. It is not improbable, therefore, that the ordinary rapid-fire gun, firing fifteen or twenty well-aimed shots a minute, will remain a favorite over this new type of gun. And yet upon occasion sixty nine-pound projectiles a minute might decide an issue, on land or sea, if poured in at the right time, even if not accurately aimed.

And one of the features of the semi-automatic nine-pounder—the "semi" feature, indeed—is that it may be used like an ordinary rapid-fire gun, firing as slowly as desired.

GUN CARRIAGES

The revolution that has taken place in guns during the last quarter of the century could not have been possible had it not been for an equally wonderful and revolutionary change in gun carriages. Rapidity of fire had been made possible by the introduction of the breech-loader, fixed ammunition, and percussion or electric fuses, but even with these rapid fire could not have been produced without the modern improved gun carriages. This is true at least with all pieces of ordnance larger than the ordinary rifle.

The great difficulty to be overcome in heavy ordnance is the force of the explosion.

If the trunnions of a gun were fixed in an absolutely rigid and immovable socket, it is probable that the force of the recoil would destroy the gun at the first discharge; for, of course, the backward and natural pressure of the explosion of the propellant is just as great as the forward pressure which moves the projectile. With the older muzzle-loading guns the force of the recoil was expended in the "kicking" back of the gun, the distance to which it was thrown by its discharge being limited by the breech tackle, described in a previous chapter.

In all cases of muzzle-loaders, however, this recoil was turned to account and utilized in the reloading process, as in any event the gun had to run in for loading.

One of the great contrasts between ships using

muzzle-loading guns and those using breech-loaders is an outside appearance presented by the gun decks during the action.

In the modern battle ships the guns are constantly protruded from the side of the ship, springing back a certain distance momentarily at the instant of discharge and running out again to their full length so quickly that the ports or openings in the shield are kept constantly closed and only partially exposed for an instant at the very moment of fire.

In contrast to this appearance presented by the bristling rows of gun barrels was the appearance of such a war vessel as Nelson's *Victory* at the moment before and after discharging a broadside. A moment before the discharge the side of the ship presented rows of black, gaping barrels; an instant later every gun had disappeared from view, leaving a row of port holes in their place. These port holes thus became at once a great source of danger to the gun crew from the missiles of small arms of the enemy.

To avert this danger, trapdoors for closing the ports were sometimes used, but these were very easily injured and were never entirely satisfactory.

As soon as the breech-loading cannon came into general use, therefore, efforts were made to solve the problem of the recoil so that the energy could be absorbed without throwing the gun to so great a distance to the rear. This has been accomplished by certain ingenious devices, and so

perfected that a gun when fired is not only checked in its rearward movement without injury to itself or its carriage, but is also returned automatically to the original firing position.

The manner of effecting this that would naturally first present itself would be the use of a powerful spring which could receive the recoil gradually and return the gun to its original position without moving the gun carriage. By a moment's reflection, however, it will be seen that such a simple spring arrangement would quickly destroy the gun mountings, as any spring powerful enough to check the backward movement of the piece without breaking it would also return it to its original position with a corresponding force. So that the simple spring recoil check, except as attached to very small guns, can only be employed as auxiliaries in governing the recoil and returning the piece.

A more successful method, and one which, with modifications and improvements, is now in use everywhere on practically all types of ordnance, is one in which a rod and piston fitted in the cylinder containing a suitable elastic fluid is used.

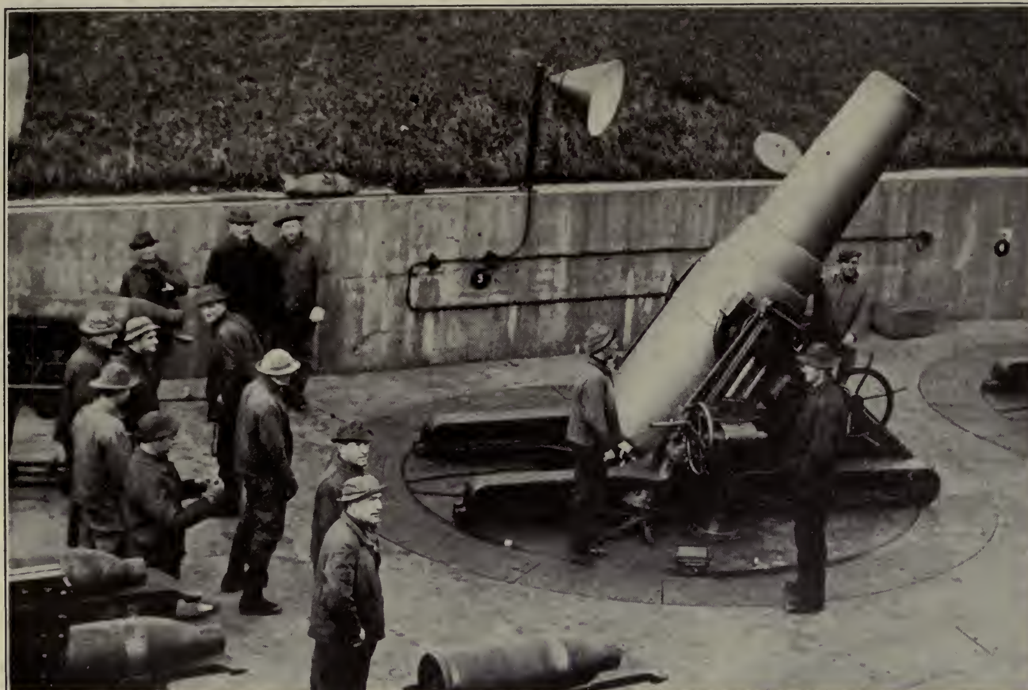
Such a mechanism as first used consisted of a simple piston made with holes through which the liquid could pass at a certain rate of speed according to the pressure given by the discharge of the gun. But it was soon found that there were certain objections to the use of such a simple mechanism, the force required to force the piston through the liquid remaining constantly the same

and thus interfering with the return of the piston, although the pressure from the recoil diminished as the force was absorbed by the fluid in the cylinder.

To overcome this defect, ingenious valves of various types were introduced, so arranged that they were closed automatically and gradually as the pressure of the recoil diminished.

They were also made so that the reverse movements of the returning gun opened the valves, thus offering little resistance to its return. A great number of modifications and improvements on valves working on this principle have been made since their invention. But the difficulties encountered have been very practically overcome by modern gunmakers, and every nation now uses hydrostatic recoil devices on its guns whose mechanism is satisfactory.

One of these recoil valves which has been found to work satisfactorily with heavy guns is that in which the closing of the valve is effected by a rotary movement of the piston as it moves along spiral grooves in the cylinder cut for this purpose, and into which the piston is fitted. This mechanism, however, is relatively slow, and interferes with a rapid return of such cannon as the rapid-fire guns. In place of this, therefore, a somewhat similar device is used, in which holes are cut in the side of the piston so placed that they run on longitudinal bars which are made of gradually increasing thickness, so that the holes in the piston are wide open at the beginning of the backward



U. S. Army Mortar for Coast Defense

movement along the bore and are gradually closed by the backward movement of the gun. These are only two among many types used on modern guns, but they serve as illustrating the principle involved in all types.

In actual practice recoil valves may be used as a " push " in or " compression " or as " pull out " or " tension " valves, but the principle involved is the same, and for the sake of gaining space or for some other special reason sometimes both types of valves are used on the same gun.

The force of gravity, in combination with valves and springs, is utilized in some gun carriages for automatically returning the gun to the firing position after the discharge. In such carriages, the gun is made to travel up an inclined plane by the force of the recoil, its own weight rolling it into place again when the force of the recoil is absorbed.

An objection to such a carriage dependent upon gravity for use on shipboard is the fact that the rolling of the ship may return it with too great violence.

Another objection is the violence of the downward blow upon the deck given by the discharge, this blow being increased in force when the gun is elevated for firing at extreme ranges. This objection, however, applies only to guns on shipboard; and in emplacements such as those used for seacoast defense guns this type of carriage is entirely satisfactory.

It must not be understood, however, that the re-

coil mechanism of any modern gun is as simple as might be inferred from this description of the principles involved. As a matter of fact, these devices are most complicated. The general principles, however, remain practically the same with all guns on stationary carriages, whether on shipboard or on land, even the "disappearing" carriages being simply the application of this principle specially adapted.

This disappearing carriage, as its name implies, is one by which the gun is caused to disappear after its discharge, the disappearance being produced by the energy of the recoil. Such guns first made their appearance about 1888, and gained immediate popularity. The mountings of such a gun are so arranged that, when in position for firing, the gun is balanced upon a metal frame, pivoted so that the recoil of the gun throws it backward and downward several feet below the surface of the surrounding fortification.

The emplacement of such a carriage is literally a "hole in the ground," the loading, aiming, and training of the gun being performed while the piece is lying on its carriage below the level of the surrounding ground.

Aiming under such circumstances may be done by signals of the position finders, indicating the position of the target; but as all harbors and surrounding land surfaces protected by batteries of such guns are charted, this aiming can be done with mathematical accuracy. Once the gun is sighted, which is done during the loading process,

it can be raised into firing position and discharged at once, so that at most only the muzzle can be seen by an enemy, and this only for a moment.

The loading process is simplified and facilitated by the fact that the recoil throws the piece directly back into position for loading.

The rate of fire from the modern twelve-inch disappearing gun is about ten rounds in seventeen minutes. During the entire process only the head of the man who aims the gun and the momentary protrusion of the gun's muzzle are seen. With smokeless powder the chances of detection of the location of these batteries by the enemy in an action is very remote; and from the fact that such guns are usually fired with the barrel raised at an angle, it is possible to conceal even the momentarily protruded muzzle by shrubbery planted about the edges of the emplacement without interfering at all with the fire of the piece.

The only sure way of detecting the exact location of such batteries would be from balloons or aëroplanes.

The probability of deceiving an enemy and diverting his fire in a false direction is greatly increased with such batteries of disappearing guns.

Examples of this sort of trickery are said to have been practiced on several occasions by the Boers in South Africa with rifles using smoky powder and those using smokeless ammunition.

In several battles the Boers are said to have stationed a line of men within sure rifle range of the British, concealed in the undergrowth, these

men being armed with smokeless powder rifles. On adjacent hills to the rear of this line, and at long rifle range, another line of men were stationed, armed with smoky powder weapons. The smoke from the discharges of the rifles of the men in the rear line would divert the attention and draw the fire of the advancing British line, which could be cut to pieces by the fire from the smokeless weapons of the front line.

Similarly with batteries firing smoky powder, carefully protected by shell-proof fortifications, and located some distance from the disappearing guns, the enemy's attention could be diverted from the real source of the shell fire hurled against him. At close range the deception would soon be discovered as the so-called smokeless powder is not absolutely so; but as such engagements would usually be carried on at long range, at least for some time, it might happen that the enemy's ships might be beaten off or destroyed without ever discovering the source of their destruction.

Of course the use of disappearing carriages is confined mostly to the guns of heavier natures, but in the United States even such relatively small guns as the six-inch quick-firers are sometimes mounted on disappearing carriages. For the smaller ones the same kind of protection is given as to guns on shipboard, that is by turrets, barbettes, or shields, with such additional protection as mounds of earth. Some of these turrets are made as "disappearing turrets," being so made

that the guns can be run in and the top of the turret closed down when the fire of the enemy becomes too hot.

FIELD ARTILLERY

The field artillerist is presented with difficulties in overcoming the recoil of his gun quite different from those of the naval or coast-defense gunner. His problem is one concerned with a weapon that must be quickly convertible from a mobile to a stationary one, and *vice versa*. With the relatively heavy pieces, such as siege guns, in using which the time element does not matter so largely, the problem is perhaps less difficult than with the field pieces proper, as such guns may be dismounted and converted into stationary guns; and the carriages of such guns can be made relatively heavier than those of the ordinary field pieces.

Generally speaking, however, until very recently, the field gun with its carriage has been limited to a weight that can be drawn readily by six horses, and this limitation made the enormously heavy steel forgings such as are used by stationary guns out of the question. But the use of automobiles has done away with these restrictions, as we shall see when the developments of the great war of 1914 are under consideration in a later chapter.

In the older field cannon of forty years ago, and for two centuries preceding, no attempt was made to overcome the energy of the recoil, the

backward spring of the piece taking up this energy. After each discharge, therefore, the cannon had to be run up by hand into firing position. This was slow and laborious work, as was also the loading process.

Quite a common practice was to fire such guns from the brow of a hill, the recoil throwing the gun back out of range of the enemy's guns during the reloading.

With the introduction of breech-loading field pieces, however, methods were attempted to control this recoil of the gun, as so much time was lost by it, and the methods used on stationary guns were tried. But as a rule such mechanisms were found too heavy for practical application. Various forms of brakes were then tried, and while these have been made to do some good service in actual practice they are not perfected and are being constantly experimented with and improved.

A very common method of controlling the recoil is by means of a "plow" attached to the axle, a "spade" attached to the trail, in combination with a brake applied to the wheels.

The plow, when attached to the axle or some other part of the carriage, reaches downward far enough to be thrust into the earth at an acute angle backward. This plow is not merely a rod of iron but is frequently of complicated structure, made as a cylinder, piston, and piston rod, arranged to absorb the energy of the recoil in something the same manner as the recoil cylinders of

stationary guns. Another method of using the plow is by means of a pull-out piston and cylinder placed on the trail of the gun, and attached to the plow by a cable, in such a manner that the energy of the recoil is transmitted from the plow to the mechanism of the cylinder.

The spade is made in the form of a fin-shaped piece of metal placed on the end of the trail coming in contact with the ground, and arranged so that it digs its way into the dirt and holds the gun firmly in place. When this is used, recoil cylinders and springs are attached to the gun for absorbing the recoil, just as in the case of stationary guns. And indeed this spade acts so well that the mobile gun carriage becomes practically a fixed piece so long as the spade is in place.

The brake, when used with the plow or spade, is simply some apparatus for holding the wheels stationary, to help in resisting the recoil of the gun. These brakes are of various patterns, all of them fairly satisfactory, but none as yet that are not open to certain objections. Most of the European countries are struggling constantly to perfect this essential part of their cannons, and the greatest secrecy is maintained in these experiments.

It may be recalled that the unfortunate Dreyfus affair in France a few years ago grew out of the supposed divulgence of the secret of one of these military brakes.

The object of all these appliances is to increase the rapidity of fire of the guns, the other qualities

not being affected by them. This is significant as showing the trend of ideas in field artillery at the present time. The modern field gun must be mobile and a quick-firer, even at the expense of some other qualities that were formerly supposed to be quite as essential.

The United States, although probably not as deeply interested in the matter of a perfected field gun as some of the European nations, is nevertheless equipped with a very effective weapon. Its carriage is of the brake and spade type, and the following is a brief description of the gun itself by Captain George W. Burr, of the Ordnance Department:

" The gun is a built-up nickel-steel rifle consisting of a tube, jacket, locking hoop, and clip. On the outside of the piece, extending the whole length of the jacket, locking hoop, and clip, are formed two recoil clips, which fit over and secure the piece to the guide rails of the cradle.

" The breech mechanism is of the interrupted screw type. The breech is opened or closed by a single horizontal motion of the operating lever which is pivoted on the carrier immediately under the block. The gun may be fired by a lanyard attached to the sear catch on the right side of the cradle. In case of misfire the firing pin can be cocked without opening the breech.

" The breech mechanism has been exhaustively tested and has been found decidedly superior to other systems of breech closure. Among its advantages may be enumerated: rapidity of fire;

Monster Coast Defense Gun of England on the Straits of Dover

great power of extraction and ejection and also of rotation; ring form of extractor; ease of loading, in that the cartridge does not have to be pushed home by hand; protection of parts from dust or injury; simplicity of parts, few in number, and easily assembled or dismounted without tools; safety insured by eccentric location of firing pin, as well as by provision making impossible the release of the sear before the gun is fully closed.

" The weight of the piece, with breech mechanism complete, is 832 pounds. The diameter of the bore is three inches; total length of bore, twenty-eight calibers; total length of piece, 87.8 inches. Weight of the projectile, fifteen pounds. The range of the piece at 15° elevation is 6250 yards. By sinking the trail of the carriage in the ground a greater elevation can be obtained with correspondingly greater range."

VIII

GUN SIGHTS AND RANGE FINDERS

PERHAPS no single feature of firearms was perfected so early and has remained so little changed, at least in principle if not also in actual methods of applying it, as the open gun sight.

Modifications and additional mechanisms have been added as supplementary adjuvants, such as wind gauges, spirit levels, gauges for making allowance for a ship's movement, etc., but the general principle—that of two points corresponding with the axis of the bore of the gun brought into line with the target—has remained unchanged for at least three centuries.

A most natural type of sight would be one made of a small tube placed parallel with the axis of the barrel. If the bore of this tube were extremely small it is obvious that accurate aim might be taken by looking through the tube and bringing the target into the field of vision. Such a sight could be used, and has been used, with good results in target practice, but it has many disadvantages. The field of vision is very limited on account of the necessarily small caliber, and good shooting, in anything but target practice at least, is dependent upon clear vision about the

sights, as well as along the sights themselves. Such simple tubular sights, therefore, are not used; but the principle involved is utilized in two of the three popular forms of sights in common use, the telescope and the " peep " sight.

The same effect could be obtained by two uprights, with a knob at the top, one located near the base of the gun and one near the muzzle, so placed that a straight line drawn between the two knobs corresponds with the axis of the bore of the gun. But in attempting to use such a sight a difficulty would be at once apparent. The knob near the breech, being much nearer the eye, would appear so large that the sight on the muzzle would be hidden. An improvement upon this would be to leave this knob for a front sight, but for a rear sight use some aperture, slot, or notch, made at a certain height so that the point of the aperture or notch was exactly on a level with the knob of the front sight.

To take exact aim with this sight it would only be necessary to hold the weapon so that the point of the notch, the ball on the tip of the foresight, and the target were in line.

This style of sight, the " open," " crotch," " notch," or " block " sight, with various modifications, is the one still in use on hunting and military rifles for ordinary shooting.

It is obvious that the farther apart these two sights are placed on the gun barrel, the less danger there will be of errors in shooting, or rather the smaller will be the deflection of the bullet if

the sights are not absolutely in line with the target. On the other hand, a sight of this kind placed too close to the eye appears so large that the contour of the point of the notch is lost entirely. A compromise is made, therefore, by placing the rear sight just far enough from the eye so that the notch will be clearly defined and not too large.

When distant objects are to be fired at, necessitating the holding of the gun at an angle, it is evident that this sight could no longer be used in the same way. It is necessary, therefore, to elevate the rear sight to a height so that when the gun is held at the necessary angle the knob of the front sight and the point of the notch in the rear sight are in a straight line.

This is the principle of the ordinary elevating sights, and applies to all kinds of sights, whether open, telescope, or peep, on small arms as well as cannon.

Of course, in the practical application of sights to guns, many things have to be considered; and this is particularly true as regards rifled cannon. Rifling causes the projectile to be deflected slightly in the horizontal plane, left-hand rifling causing this " drift " always to the right, and *vice versa*—on the principle of the ball pitcher's " curved ball." But this can be corrected approximately in practice by testing the gun, and setting the rear sights at the necessary angle. Wind gauges must also be used, gauges for making allowance for the ship's motion, and spirit

levels; but all these are necessary details of "making ready" the sight. The marksman himself has nothing to do with these preliminaries. At the moment of actual firing he uses only the old principle of bringing the target and the front and rear sight in a line with his eye.

Every country has its own particular pattern of sight which it considers best suited to the use of its gunners, but the principle of all these is necessarily the same.

For shooting at ordinary ranges with cannon the British navy uses a front sight which consists of a small ball, or bead, placed on an upright. The rear sight consists of a fine wire stretched horizontally between two uprights, which has the appearance of the letter H. To aim with this sight the bead of the front sight is brought into line with the eye so that it appears to rest on the center of the horizontal wire—a dot on the crossbar of the H, as it were. The gunner must guess at the exact point of the center of the wire, but for practical purposes this is not difficult, and the advantage of the clear view and wide field of vision possible with such a sight makes it an excellent one in actual use.

The sight used by the American gunners is very much the same as this one, differing chiefly in various details of construction.

Such a sight, of course, is worthless at night, for even when there is sufficient light as that such an object as a ship on the water can be distinguished, the sights on the guns cannot be seen

clearly. To overcome this difficulty certain types of night sights are used.

It is evident that a strong light thrown upon the gun barrel, if strong enough to make the sights plainly discernible, would obscure the target, unless it were a brilliantly lighted one. It has been found by experiments, however, that if the sights are dimly illuminated they may be seen without obstructing the view of the target. To accomplish this, small electric lights are placed at the fore and rear sight so concealed that only a reflection from them is made upon the portion of the sight to be used.

In order that the gunner may distinguish between the front sight and the rear sight these are frequently lighted with different colors, the front sight being the ordinary yellow light and the rear sight being some dim color, such as red.

With such sights the ordinary shape of the daylight sight is not practical and various forms and modifications have been introduced to replace them. A very simple form is one in which the sight of the gun when brought into proper alignment presents three bands of light, a yellow one with a red one running parallel with it on either side. When the sights are so placed, and the target appears as bisecting these three bands of light, the gunner knows that his piece is aimed with absolute accuracy.

This device of the three bands of light is only one of the many forms in use, and simply replaces the daylight sights for laying the piece. The

range, speed of the vessel, or the movement of the target are determined and made allowance for by the same mechanisms as used in daylight, the scales and indicators being lighted by electric lamps arranged for the purpose.

The sights which we have been describing are those used for firing at ordinary distances.

At long ranges, however, telescopic sights are used. Such sights utilizing the principle of the telescope for making a target appear nearer and larger, are made of various patterns, the most common form being that of a long tube so arranged that two fine wires crossing the tube at right angles give the correct aim when the point of intersection of the two wires appears to cover the target. This is a modification of the device used by the astronomer in star-gazing.

Another form of sight is what is known as the "peep" sight. In such sights the front sight is in the form of the ordinary knob or bead supported on an upright in practically the same manner as in the case of the open sight. The rear sight, however, which is placed in a position close to the eye of the gunner, consists of a plate or ring of metal with a pin-hole opening in the center. This pin hole is so placed that a straight line drawn from the center to the bead of the fore sight corresponds to the axis of the bore of the gun.

It is obvious, therefore, that in taking aim with such a sight the gunner has but to look through the pin hole in the rear sight and bring the bead

of the front sight into a position where it appears to rest against the target.

This would seem to be an almost ideal form of sight, as there could seemingly be very little variation in the position of the rear sight because the vision of the gunner is confined to the diameter of the pin hole; and in actual practice this is an extremely accurate form of sight.

To anyone who has ever tried the experiment of looking through a pin hole, however, it will be recalled that even the smallest pin hole when brought close to the eye appears to be greatly enlarged, the pin hole seeming to form a circle perhaps several feet in diameter. If now the bead of the front sight, which appears as a small speck inclosed by a large circle, is brought to a point as near as can be estimated to the center of the large ring made by the rear sight, the aim will be very accurate. If, on the other hand, the gunner, in taking aim, allows the bead of the front sight to appear at one side in the circle instead of the center, a deflection of the bullet will take place, the amount of the deflection corresponding to the distance between the center of the pin hole or sight and the point away from the center at which the bead appears to rest at the moment of firing.

This distance is, of course, infinitesimal, and at short ranges will not be enough to prevent excellent marksmanship; at increased ranges, however, even these slight deviations through the central line may cause the ball to go wide of the mark.

Fourteen-inch Sandy Hook Gun

There are two vital objections to the peep sight. One of these is the fact that as the rear sight is necessarily placed close to the eye, injury to that organ may occur as an effect of the recoil of the gun. If this were the only defect it could probably be overcome; but an equally important objection, and one that cannot be easily remedied, is the fact that such sights are not adapted to rapid firing because with the peep hole sufficiently small for accurate shooting it is impossible to adjust the eye quickly to the aperture. For sporting purposes and target shooting, however, this sight is a favorite with many marksmen.

One of the modern improvements in sights for cannon is the arrangement of the sight on the gun carriage which absorbs the recoil, instead of on the gun barrel itself.

As the sights so placed are not affected by the recoil of the gun, the man who is doing the sighting need not remove his eye from the target at the moment of firing—a thing of great practical advantage in using rapid-fire guns. There is also much less liability to injury to the sight itself when so placed, and in all modern guns larger than the rifle and the machine gun the sights are now placed on the carriage instead of the barrel.

RECENT TYPES OF GUN SIGHTS

As the long-ranged rifle cannon came into general use, and long-distance shooting gradually replaced the older form, it was evident that the or-

dinary type of open sight must be improved upon. The possibilities of the human eye fell far short of the possible ranges of the new guns, and naturally some aid must be given them if the defect was to be remedied. The natural solution of the problem was, of course, the telescopic sight; but there were many who opposed this sight, and still argued in favor of some form of plain sight.

In rebuttal, the advocates of the telescope sight pointed out that aiming with the ordinary open sight, where three objects at different distances from the eye had to be brought into alignment, was a physiological impossibility.

The German expert, Von Kodar, in speaking of this, makes the following statement: "There is no doubt that this method of aiming (i.e., with open sights) would be very perfect, if the qualities of our eye would not make it impossible to align simultaneously three points situated at different distances. Everybody knows that in looking at a distant object our eye automatically accommodates itself to the long distance, and then objects nearer us are only dimly visible, and *vice versa*. Therefore, it is quite out of question for the eye to perceive simultaneously and distinctly the rear sight, quite near the eye, the front sight a small distance off, and the far-away target."

It is true that in actual target practice the marvelously accurate shooting of good marksmen seems to discredit the applicability of this theory; but although the marksman learns to overcome the difficulty, he is constantly confronted with it.

For this reason there have been numberless attempts to produce a sight that overcame this initial defect, and at the same time had no more serious ones. And there are now several of these, both plain and telescopic, that are great improvements over the older types for long-distance shooting.

Some of these do away with the old three-object alignment principle entirely, the " Grubb " sight being a particularly good example of this.

In this sight, by means of a simple optical contrivance, a " ghost image " of a cross (+) is made to appear as if projected upon the object aimed at. In aiming with this sight it is only necessary to point the weapon so that the cross shall appear superimposed on the target. It is a small and compact little device, which may be attached to the ordinary rifle, as well as to the largest cannon, without interfering with the ordinary sights. For cannon it may be connected electrically so that an illuminated cross is used for night shooting.

It is made in the form of a short metallic tube, the rear end of which is closed by a window of parallel plate glass, having the lower portion silvered, while the upper is left transparent. The front end is closed by a piece of glass having a convex curve on the outside and a concave curve on the inside. The concave surface is coated with a semi-transparent and highly reflective film, and is slightly tilted. At the top is a projection in which is a diaphragm, usually of glass covered

with an opaque substance. On this is cut the cross or any other design, if preferred, which is to be projected on the distant object.

The following details are given by Mr. H. C. Sheridan:

" The rays which enter the eye to form the image of the cross diverge from the cross (which may be considered as a luminous object) and are reflected (still diverging) from the silvered portion of the back window on the concave surface of the front window, which is coated as described with the reflected film referred to above, and thence through the upper part of the back window to the observer's eye. The inside surface of the front window is of such a concavity that it parallelizes the formerly divergent rays, and causes them to enter the eye as parallel rays, or in effect, as if they had emanated from a large cross on the distant object itself instead of from a small cross close to the observer's eye, consequently there is no ' parallax,' a fact easily tested by anyone by moving the eye backward or forward, or up or down, on looking through the sight; such movement will be found to produce no effect in the coincidence between, or superposition of, the cross and the object; in fact, to quote an article in *Engineering,* ' it is like a fore sight carried on the end of a pole attached to the barrel. Evidently, if the barrel could be so far extended that the marksman could place his fore sight on the chest of his enemy there would be no need of a back sight at all, and that is exactly what is done by

this sight.' The fixity of the eye of the observer not being necessary there is no necessity for a back sight—a very important advantage in itself, more particularly when firing in a constrained position, as is often necessary in warfare."

As will be seen from this description, this sight is not essentially a telescopic one. But there is no difficulty in adding a telescopic attachment to it, and using it in the same manner as described above. As the little brass tube occupies very little space it can be attached to the ordinary military rifle, and used for long-range shooting and sharpshooting.

But for ordinary rough-and-ready firing it is probable that some sight more nearly like the older form of open sight will remain the favorite, both with hunter and soldier.

RANGE FINDERS

As implied by the name, the range finder is the instrument used by the gunner for determining the distance of the target.

At the present time nearly all range finders of any practical value may be described as instruments that "automatically solve the triangle." For the action of practically all of them is based upon the geometrical fact that if two angles and the length of one side of a triangle are known, it is possible to determine the length of the other two sides. It is true that several other types of instruments have been found to be more or less

practical, some of these being made on the principle of the camera obscura or the stereoscope, but as yet these instruments have not been entirely successful.

Even before the days of modern long-range weapons, several different kinds of range finders were in use. Perhaps the simplest of these was what was called the "acoustic" range finder, the use of which, as the name implies, depended upon the sense of hearing and the knowledge of how fast sound travels. To use this instrument the operator watched the flash, or the puff of smoke from the enemy's guns, and timed the interval that elapsed between the flash and the sound of the report.

This could be done roughly by timing with an ordinary watch, but a more accurate measurement could be made with a specially devised instrument.

This consisted of an upright tube filled with fluid, so arranged that it would fall in the tube at a known rate of speed when a certain button was pressed, stopping when this was released. This tube was marked off into a scale which corresponded to the distance traveled by sound waves. To get the range of an enemy the operator simply watched until he saw the flash of the enemy's gun, pressing the button instantly, which allowed the fluid to descend in the tube until the report was heard, when the button was released.

The point marked on the scale where the fluid stopped would give the approximate range in

yards; indeed, under favorable conditions, the exact range could be determined.

But the great difficulty in using this instrument lay in the fact that conditions were seldom ideal: were, in fact, usually such that it could not be used at all. For example, it could only be used in cases where the enemy was allowed to open fire first; for of course, once the din of battle was on, the instrument was useless. This defect in itself was sufficient to condemn it. And when shortly after its invention smokeless powder came into use, even its hitherto limited field of usefulness quite disappeared.

But meanwhile other and better range finders were in course of development. Most of these never became practical instruments; but at least three types have been found practical, and are in use at the present time, and all of them act on the simple but all-important underlying principle of solving the triangle.

The different types are necessary to meet three entirely different conditions—the position of fixed batteries, as in forts; the positions of field guns; and for use on shipboard.

Where the guns are stationary, as in fortifications, two fixed points at exactly known distances may be established, and electrical connection made between these points which represent one side of the triangle to be solved. As the instrument used at one of these stations acts at a known angle, readings from this communicated to the other station will enable the operator to determine the

sides of the triangle formed by the target, his own station, and the other station.

This would be a horizontal triangle, easily solved, but the fact that two operators are required to take the observations is a serious drawback.

For seacoast fortifications a vertical triangle may be used where the observation stand can be placed far enough above the sea level so that the surface of the water can be used as one of the points of reckoning. Thus, if the observation tower is fifty feet above the level of the water, there will always be the fifty-foot side of a right-angle triangle from which to make reckonings, the only variation being that made by the tides, which can readily be determined.

A similar method of using a vertical triangle can be used also on war vessels where a point on the bridge or fighting top is far enough above the water, although in practice other methods for range finding are used in most navies, as having greater reliability.

Several range finders have been devised for operating in the open field, but most of these require more than one man for making observations. A very common form is one used by two observers who are kept at a fixed distance apart by a measured steel tape line held tight. As these two observers must keep at least twenty-five yards apart, communications between them may be misunderstood at times; but on the whole this method of finding ranges is very satisfactory, although,

of course, any range finder requiring more than one man is not ideal.

In artillery fire the exact range is determined by firing a few test shots after the approximate range has been determined by the finder. For this purpose a shell is fired from a gun given an elevation corresponding to the range as found by the range finder, the bursting point of the shell enabling the gunners to find the exact range of a stationary target by a few shots. But with artillery fire there is still another thing to be determined after the range is found. This is the correct timing of the shell—the turning of the fuse to a point so that the explosion will occur at the right moment. Knowing the range helps in determining this, of course, and although it might seem almost impossible to time a shell so that it will burst at an exact point several miles away, in point of fact the gunners are able to do this very accurately after a few trial shots, as amply demonstrated in modern warfare.

The range finders in use by most navies, while often extremely complicated in their internal mechanism, are usually very simple to operate; and it is possible for any person of average intelligence to learn to use them accurately after a few hours of training. Indeed, it is the boast of the naval men that with their range finders exact ranges can be found in ten or fifteen seconds, even by tyros of a day's training. In this type of range finder prisms are set at such an angle that their known positions and the angle at which they re-

flect light are made to take the place of the second angle of the triangle to be determined.

The naval gunner has even a better chance than the land artillerist to determine the exact range by watching his shots, although after the first few seconds of firing this is impossible except in a general way, as it is impossible for any one particular gun crew to distinguish their shots from those of a dozen others on their own boat.

Many different devices have been tried for transmitting signals from the range-finding stations to different points. Telephones are very satisfactory in many ways, although frequently rendered useless by the unavoidable shock of the firing. But perhaps the most practical means of communicating is by means of the telautograph, the instrument that reproduces handwriting at a distance. Many stations are equipped with these instruments, but usually have telephonic communication as well, since this is so much more rapid and satisfactory while it remains in working order.

IX

THE EVOLUTION OF THE BATTLE SHIP

STUDENTS of ancient history will recall that the Romans, after adopting the Greek type of galley with its many tiers of oarsmen, finally discarded this type of boat, for vessels with a single, or at most a double, bank of rowers. And it is probable that this type of vessel, fitted with masts and using sails of various shapes, was the popular one in use throughout early medieval times. But the sources for our knowledge of the medieval war vessel are most meager, as very few authentic records of such vessels have come down to us. It may be taken for granted, however, that there were no important innovations or improvements, at least until late in medieval times, as the Dark Age was not a period of improvement in shipbuilding any more than in other mechanical arts.

During the period just preceding the introduction of gunpowder, war vessels were still of the galley type, propelled by one or two tiers of oarsmen and fitted with masts and sails.

In such vessels the oars used were much longer than the average oar used by the Greeks and Phœnicians in antiquity, and several men sometimes worked upon one oar. This was a distinct

departure from the method of either Greeks or Romans, as in their vessels only one man worked at an oar, regardless of its length. The strokes taken by the ancient oarsmen were, therefore, of the paddling type, rather than the long sweep of the medieval rowers.

In the Greek ship the long oars of the upper tier of rowers were weighted on the short hand piece between the rowlocks and the handles, by pieces of lead acting as a counterpoise. In the medieval galley the length of the handle acted as a counterpoise, and to overcome the over-reaching of this long handle in a narrow boat, wooden outriggers were introduced. These outriggers, with a lengthened section of the oar within the ship, constituted probably about the only modifications made in the general principle of the galley during the Middle Ages.

The masts in use during the thirteenth century were short and heavy pieces of timber, having at their top a round box large enough to contain from two to six men, in appearance resembling the fighting top of the modern warship. It was the duty of the men in this fighting top to hurl missiles down upon the deck and into the hull of the enemy's ship. For this purpose heavy stones and javelins were hauled up by means of ropes arranged for the purpose, and it is asserted that the fragments of rock so hurled frequently pierced the hulls of the ships, showing the comparatively fragile construction of the boats at that period.

The principal part of the fighting was done by

soldiers in armor protected by shields arranged along the side of the boat, and standing on a platform built above the heads of the oarsmen.

At either end of the ship was a "castle," which was made with one or more decks, upon which were mounted the military engines for hurling fire pots, heavy arrows, or javelins. Such machines were usually of the catapult type, and were sometimes called "springalds."

Firing was of course mostly at very close range, and if the weather gauge could be secured by a vessel the soldiers of the fortunate boat often threw unslaked lime into the faces of their enemies, blinding them and burning them. This form of attack was the most terrible known in warfare, being even worse than the dreaded Greek fire. For even a few grains of the lime would produce permanent blindness, and when particles of it were carried by a strong wind there was practically no escape from it.

The prow of such a vessel was fitted with a heavy spur projecting some distance in front for use in ramming. Against the frail side of the thirteenth-century boat this method of attack was practically irresistible.

During the reign of Edward III in the fourteenth century gunpowder came into use very generally, and cannon was soon introduced on shipboard, and at about the same time sails gradually displaced the oarsmen, although in the Spanish "galleons," used in the time of Henry VIII, oarsmen were still employed in small numbers, being

placed alternately with the cannon along the sides of the boats.

By the time of Elizabeth portholes had been introduced, making possible the use of two tiers of guns. This method of placing guns is said to have been suggested by Descharges, a shipbuilder of Brest. Before the close of the sixteenth century ships with two or three gun decks had come into use, and the masts had been increased in number and lengthened.

Some of the ships of this period carried as many as one hundred and twenty-two guns, being longer and narrower than the ships of the preceding century, more nearly approaching the shape of the modern frigate.

In the seventeenth century little actual improvement was made in war vessels, but there was the general increase in their size over the boats of the preceding century. The great English warship called the *Sovereign of the Seas,* for example, was a three-decker, one hundred and seventy-three feet long and fifty feet wide, with a hull twenty feet deep. She was of one thousand eight hundred and sixty-one tons displacement (one-tenth the size of a twentieth-century dreadnought), and carried about one hundred and fifty guns. At this period the great " castles " at the bow and stern were still in use, the stern of this warship being at least fifty feet out of the water. The disadvantage of such structures had become apparent, however, and the *Sovereign of the Seas* was eventually cut down so that her appearance was much the same

as that of a frigate of the early nineteenth century.

In the eighteenth century the modifications in warships were most directed to improving their structure, perfecting pumps, and increasing their size, and there was little change in the general appearance of such boats. Some of these vessels built at the close of the century were over two hundred feet long, fifty feet wide, and of more than twenty-five hundred tons' displacement.

In other chapters the apparent stasis in improvements in firearms, particularly cannon, between the beginning of the seventeenth century and the beginning of the nineteenth century has been referred to. During this period there seems to have been a corresponding stasis in the progress of boat building, although there had been considerable improvement in the shape and arrangement of the sails, and boats had become more manageable and were much better sailers.

Most of the guns were arranged in broadside, and the bow and stern fire of such vessels was particularly weak and ineffective; in fact, this was true even of modern steam war vessels until the comparatively recent introduction of turrets.

The introduction of the steamboat had little effect upon war vessels for some time, as the space taken up by the machinery and paddle wheels, and the vulnerability of this machinery, more than compensated for the advantages given by the steam power. On the introduction of the propeller, however, steam war vessels came into favor, the first vessel of this type ever built as

a man-of-war being the *Princeton,* launched in the United States in 1842.

But such vessels by no means entirely supplanted the old sailing ship of the line, and the improvements made were mostly those directed to changing and improving the guns rather than the ships themselves.

The first and greatest revolutionary movement was the introduction of iron plates on battle ships at about the time of the Crimean War; but the really great revolution in shipbuilding did not come until several years later, after Ericsson had built the famous *Monitor.* An indication of the lack of progress in shipbuilding up to this time is shown in the fact that of the two American war vessels destroyed by the *Merrimac* on the day preceding her battle with the *Monitor* one was a sailing vessel.

THE "MONITOR" AND "MERRIMAC"

On March 9th, 1862, a duel between two iron-clad battle ships took place, one a vessel of the old type, given protection by iron plates, the other an entirely new type of war craft.

The older type of vessel, the *Merrimac,* many times the size of her odd-shaped antagonist, was an iron-plated war craft of the old broadside type, made to take and give a pounding of metal to the bitter end.

The other, the *Monitor,* was the first representative of an entirely novel development in ships of

Naval Combat between the "Monitor" and "Merrimac," Hampton Roads, March 9, 1862

war—a turret ship, carrying two guns only, but made invulnerable by its peculiar shape and arrangements for protecting its meager armament.

The result of this remarkable battle between an old idea and a wholly new one was a drawn contest—in the sense that neither vessel was sunk or captured. But in reality it was a monumental victory—a veritable Trafalgar, in its effects. For with the withdrawal of the *Merrimac* from the contest, thus tacitly admitting that she could not master her little antagonist, not only was the fate of the Confederacy sealed, but the death knell of every naval vessel in existence, save only the little "Yankee cheese box," was sounded.

The mid-century ship of the line, the modern propeller, and the iron-plated frigate, forming the most formidable part of European navies at the time, became by this single coup obsolete types of fighting craft—curiosities of ancient warfare, models of which would henceforth be exhibited in museums side by side with Greek trireme and Roman galley, as examples of war vessels of days gone by.

So the story of the *Monitor* has unique interest and incalculable importance.

Early in the Civil War the Northern troops were obliged to evacuate Norfolk with its docks and shipping. In these dockyards at the time was the sixty-gun frigate *Merrimac,* and in order to prevent her falling into the hands of the Confederates, she was burned and sunk by the retiring Federals. She appears to have sunk, how-

ever, before any great damage had been done to her hull and machinery, and soon afterwards she was raised by the Confederate engineers. The Confederacy at that time had few boats and few resources for building a navy, while the North had a rapidly increasing fleet of modern vessels. One vessel more or less, therefore, could make little difference in the issue, unless such a vessel could be made so impregnable and so formidable that she could cope with a fleet of ordinary ships.

At that time iron war vessels were being built for European navies, based on the experience of certain armored ships in the Crimean War, but the actual value of such ships in battle had not been determined, and many of them were still in various stages of construction on the ways in the shipyards. The possibilities of what might be accomplished by such protected vessels was discerned by the Confederate authorities, and it was determined to remodel the captured *Merrimac* into an iron-clad which might hope to destroy the wooden fleets of the Federals. To do this all the upper works of the vessel were removed, and replaced by a rectangular casement which occupied the central position of the boat for about one hundred and seventy feet. This was made of heavy timbers covered with two layers of iron plates made from railroad rails, this plating of metal extending from two feet below the water line to seven feet over the gun decks, and sloping at an angle of about forty-five degrees for deflect-

ing cannon balls. The top of this casemate was made of iron grating, which afforded light and ventilation, while only a funnel and iron-plated pilot house protruded above it. The armament of this new battle ship was ten guns: two one-hundred-pounders at either side of the casemate; and one seven-inch rifle and three nine-inch smooth-bores on each broadside. By this reconstruction the *Merrimac* became one of the most formidable fighting craft afloat, and absolutely invulnerable to ordinary wooden frigates.

The news of the converting of the captured *Merrimac* into an iron-clad reached the North soon after it was begun, and occasioned great uneasiness at Washington; but several months elapsed before any definite action was taken to avert this impending disaster to the Northern navy. Then the Navy Department, becoming thoroughly alarmed, invited proposals for armored ships. In response came the proposal of John Ericsson, a Swede who had chosen America as his home, to build a boat on a turret plan, for which he had made designs some eight years earlier—designs that had been rejected by Louis Napoleon.

The novelty of Ericsson's suggestions and the urgency of the case at last led to a provisional acceptance of his plans. The new vessel was to be completed within one hundred days, at the builder's own risk, and not to be accepted unless she proved successful. The limited time allowed was on account of the rapidly approaching completion of the *Merrimac*.

Ericsson's creation, which he called the *Monitor,* was one of the most remarkable appearing fighting boats ever designed. At a little distance it appeared like a short oval raft, on which was placed a round " turret "—a " cheese box," as it was derisively called—from two openings in the sides of which protruded the muzzles of the two guns. The boat was, in fact, a sort of steam raft with a ship's bottom, her decks being two feet out of the water. She was one hundred and seventy-two feet long, and about one thousand tons' displacement, and her armament consisted of two eleven-inch smooth-bore guns. But while apparently outclassed in every essential point by such a boat as the *Merrimac*—in size, speed, and number of guns carried—there were two points in which she outclassed any war vessel ever built before. These were her invulnerability to shot, and the fact that her revolving turret allowed her two guns to be fired in any direction with equal facility. Besides this, she sat so low in the water that the target she offered to the enemy was small and difficult to hit.

The revolutionary idea of a revolving turret, now for the first time practically tested, had been conceived by the American, Dr. T. R. Timby, some twenty years before, and the validity of his patents, the first taken out in 1843, was recognized by the company that financed the building of the *Monitor,* and a substantial monetary payment made him for the right to make use of the principle of the revolving turret. It may not be

strictly just, but it is in accordance with the precedents of history, that the chief honor was subsequently given to the man who practically carried out the idea of the revolving turret, rather than to the one who conceived the idea.

Within the stated time this *Monitor* was completed and hurried south to Hampton Roads.

But a few days before this the finishing touches had been given the *Merrimac,* and she had been sent out on her mission of destruction against the blockading Union squadron, which consisted of five war vessels. On March 8th, 1862, she made her first attack. Two Union vessels only of the five, the *Congress* and the *Cumberland,* were able to engage her, and these showered shot and shell against her iron sides, with no appreciable effect whatever. In return she rammed and sank the *Cumberland* without injury to herself, and forced the *Congress* to surrender after rendering her helpless.

Satisfied with this one day's work, she returned to her anchorage, intending to renew her career of devastation the following day.

The effect of the news of this victory upon the North and South can be readily imagined. To the Confederates it seemed that by means of this invulnerable ship they would be able to destroy the entire Union fleet, devastate the coast, open the Southern ports and close the Northern ones, and successfully assail Washington itself. In the North there appeared to be no way of preventing this disaster, and the night of March 8th,

1862, was one of gloom and foreboding perhaps never equaled before or since in the history of the Republic.

Meanwhile, Ericsson's little *Monitor*—with its all-essential Timby turret—was creeping along the coast towards Hampton Roads, and before daybreak it dropped anchor with the crippled Union squadron.

Bright and early the following morning the smoke of the *Merrimac* announced that she had started to complete the work begun the day before. As she neared the Federal squadron she headed for the frigate *Minnesota,* selecting her as the first victim. But before she could reach the wooden frigate the little *Monitor* steamed into her path, and greeted her with two one-hundred-and-fifty-pound balls from her Dahlgrens.

Relinquishing for the moment her purpose of attacking the *Minnesota,* the *Merrimac* turned upon her queer-looking assailant, expecting to demolish her as she had the *Cumberland* and *Congress* on the preceding day; but her shells only rattled harmlessly off the turret of the *Monitor,* or passed over her completely. Again and again she attempted to ram, but her iron prow only scraped against the iron sides of the little craft or passed harmlessly along her decks.

Meanwhile the two smooth-bores from the turret of the *Monitor* were pounding away at the iron plates of her huge adversary, having little or no effect.

For several hours this most remarkable of

naval duels continued, neither boat suffering very materially in the encounter; but at last the *Merrimac,* seemingly disheartened, and probably somewhat more damaged than her enemy, gave up the fight and returned to her harbor, leaving the little turret ship in possession of the field.

The effect of this drawn battle upon the people of the North and South needs no description. There were no European cables in that day, and almost a fortnight elapsed before Europe heard the news; but when it did hear it the effect produced was as great as upon any section in America—but for a different reason. The announcement of the success of the turret ship made it evident that ships of the old type could no longer be considered effective war vessels, and that every country must reconstruct its navy along new lines.

The broadside war vessels, built or building, had become obsolete types in a single day by this battle of "turret *versus* broadside."

If the little *Monitor* could be placed beside such a modern battle ship as the famous *Oregon,* or the newer and more formidable *Connecticut,* of the American navy, or beside the Japanese *Hatsuce,* or the still more wonderful dreadnoughts and superdreadnoughts, a casual observer would find little in common in the appearance of the single turret and low free board of the *Monitor* and the towering steel sides of the newer vessels.

But nevertheless the revolving turrets, protective decks, and armored sides of each of these larger boats are the direct development of the

" Yankee cheese box," with which John Ericsson revolutionized sea fighting. The development of guns and armor, the elevated free board, and military masts are all details of improvement, not departing from the great general principle involved in the little *Monitor* of the Civil War.

" Among the great men who saved the Union and freed the slaves," says Fisk, " one of the most important was the man of science, John Ericsson." Nor should we forget, in the same connection, the name of Dr. Theodore Ruggles Timby, whose idea of a defensive turret was the fundamental one that underlay the construction of the *Monitor* and brought about the revolution in naval warfare.

MODERN WAR VESSELS

All modern warships of the heavier type, then, are merely improved structures built upon the *Monitor* principle, and even the lighter ships, such as the cruisers, adhere as much as possible to the plan introduced by the *Monitor* of having all the machinery and steering gear below the water line.

For a time after the turret vessel came into use, similar vessels with low free board and turrets for the guns were practically the only battle ships built. But many objections were found to boats of this type as seagoing vessels. Their invulnerability was of course recognized and appreciated, and for seacoast and harbor defense they fulfilled the requirements very well. But sea-

worthiness is quite as essential as invulnerability, and the monitors did not fulfil the necessary conditions for this. They were slow, the quarters for the crew were cramped, and in stormy weather, when the hatches had to be kept down, the air below decks became almost unbearably foul.

Besides this, the guns in the turrets being so close to the surface of the water, made accurate shooting at long range impossible.

Gradually, therefore, changes were made in the structure of the monitor type of boat, and as armor became more and more perfected, it was possible to raise a steel free board about the protective deck of the monitor type, elevate the barbettes and turrets above this, and still maintain the maximum protection while gaining incalculably in the matter of space for the crew, machinery, and stores.

The introduction of torpedoes and torpedo boats, and the improvement in quick-firing guns, made it necessary for the battle ship to have a secondary battery aside from her turret guns, and places for mounting these guns; and gradually the steel upper works were added, increasing her offensive power without weakening her defensive strength. So that the modern type of battle ship, although still retaining the same general skeletal structure of monitor boats, resembles more nearly a peaceful merchant vessel or "greyhound" in general appearance than she does her "cheese-box" prototype.

Monitors closely adhering to the old type have

been built quite recently, to be sure, improved and added to in superstructure and armament, but these are only for coast-defense work and are not intended for seagoing. It should not be understood that they cannot go to sea, however, as is shown by the fact that two American monitors were sent to the Philippines during the Spanish-American War. Neither should it be understood that the modern monitor is not a formidable fighting craft, even when pitted against recent battle ships.

There are those who still believe that these "ocean bulldogs" would be a match for the largest battle ship, because of the small target they present to an enemy, and the damage they could inflict with their turret guns firing at the great sides of a steel war vessel.

Fully to appreciate descriptions of modern war vessels, something must be known of the various classes of fighting craft of modern navies. Not every naval vessel designed to take part in battles is a "battle ship," properly speaking; but such a war vessel must fall into one of several classes of boats, known either as battle ships, armored cruisers, protected cruisers, or gunboats, respectively. The terms torpedo boats, submarines, transports, colliers, etc., explain themselves.

The "battle ship" is the most heavily armored, heavily armed ship of the modern navy. She is the highest type of fighting machine, and outclasses all other kinds of vessels, and theoretically

can destroy any boat of any class other than her own.

The " armored cruiser " is one step below the battle ship in size of guns, thickness of armor protection, and general fighting capacity. She has turrets and protecting armor, but not such heavy armor as the battle ship. On the other hand, she is much faster, so that in the open sea her speed would be instrumental in saving her if attacked by a battle ship.

The " protected cruiser " has still lighter guns than the armored cruiser, and her armor is confined largely to a protective steel deck, from one to three or four inches thick, curved over her machinery like a tortoise shell. Her guns are not in turrets or barbettes, but are mounted behind steel shields. She has greater speed than the armored cruiser, theoretically at least, and could thus keep out of reach of the other two classes of boats.

Gunboats are small, unprotected cruisers, whose function is confined to attacks on light boats or lightly defended places. Such boats are not supposed to stand the brunt of battle, unless fighting boats of their own class.

In short, war vessels, like pugilists, are divided into classes, the relative strength of the one corresponding to the corresponding weight (and therefore strength, everything else being equal) of the other, the battle ships, armored cruisers, protected cruisers, and gunboats in fighting ships corresponding to heavy-weight, middle-weight,

lightweight, and feather-weight with pugilists. The heavy-weight pugilist outclasses the middle-weight, and, if both are first-raters, can defeat him with certainty; but, on the other hand, a second-rate heavy-weight might be unable to cope with a first-rate middle-weight. So with war vessels, a first-class cruiser might defeat a second-class battle ship under certain conditions.

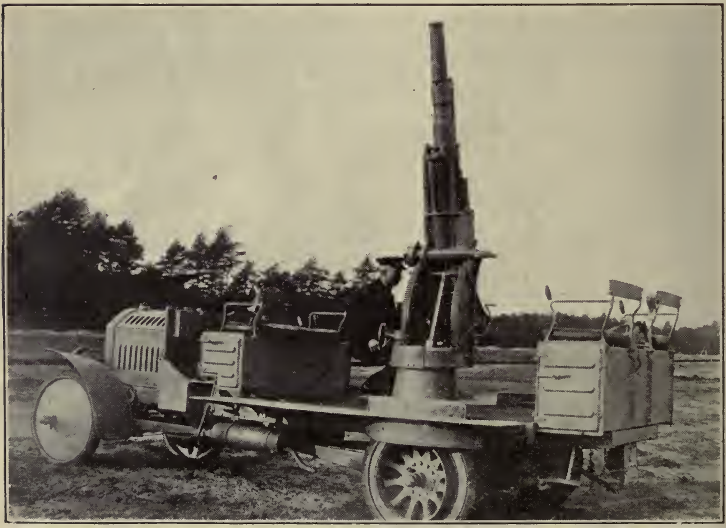
AMERICA'S NEW NAVY

One of the amazing developments of the last half of the nineteenth century was the introduction of Western civilized customs in Japan. And not the least astonishing of these adaptations was the development of her navy. Yet in actual number of years of development the modern United States navy rivals the Japanese in youthfulness. The amazing fluctuations of the status of the American navy since its birth under the guiding hand of Paul Jones is one of the curious paradoxes of history.

Forty-five years ago the United States possessed a more powerful navy than all the other nations of the globe together.

Ten years later she had practically no navy at all, even some of the South American countries making a much better showing in fighting ships. But now, in the opening years of the new century, she seems again to be climbing to her exalted position of leader in efficient navies, although there is little probability that she will ever again

Zeppelin over Army Aviation Field



Airship Destroyer

Gun for repelling the attacks of aëroplane and dirigible balloon, mounted for field use.

outclass all the world combined, as she did at the close of the Civil War.

The reason of the decadence of the great navy of the sixties was simply that the country was too busy making internal repairs to pay much attention to a navy, when there seemed no need of having one. The greatest war ever fought had been terminated within her own boundaries, and the country was sated with fighting. "Let us have peace," was the sentiment of the entire country.

But besides this sentiment there was a confidence among the majority of people that, should the occasion for needing a navy arise, there would be no difficulty in securing one in short order. Had we not done so in this very war? Ships could be bought or built as quickly as needed, most people argued, and, as a result, there was gradual dropping behind of our naval equipment, until the very name "American Navy" excited the risibilities of foreigners. But meanwhile the very inventions produced by the Civil War itself—the iron and steel battle ships, of peculiar type—had so changed the order of things naval that it was no longer possible to do as had been done in ante-bellum days. Iron ships, with peculiar guns, and not merely converted merchant vessels, could not be built in a day, or purchased at any price in an emergency.

The day of the modern navy was at hand, and the American people, having themselves taken the initial steps for its creation, were not aware of it.

By 1883, however, the appeals of the naval men for some semblance of a modern navy had had sufficient effect so that four small modern war vessels were authorized, a tiny dispatch boat of fifteen hundred tons, and three cruisers. These were the *Dolphin,* the *Boston,* the *Atlanta,* and the *Chicago.* Two years later two more cruisers and two gunboats were authorized; and the year following an act was passed authorizing the completion of four monitors whose keels had been laid in 1874. These monitors, the *Amphitrite, Miantonomah, Terror,* and *Monadnock,* were of the old Civil War type, but were modernized by the addition of recent types of guns; and although they were the source of much merriment among European naval men, they were powerful fighting machines—undoubtedly quite as powerful as some of the almost universally lauded battle ships of the period.

Another provision of the act of 1886 called for the construction of at least one battle ship of modern type, an experimental dynamite cruiser, and a torpedo boat. The first battle ship was the *Texas,* which did so many peculiar things at various times until the Spanish-American War, when she showed her mettle and proved that she was indeed a good fighter in war, even if somewhat eccentric in time of peace.

The *Maine* was also authorized in this year, and these ships, with the other vessels built or building, formed a nucleus for a navy of which no one need be ashamed.

From that time the future of the American navy was assured. Stimulated by the successes of the Spanish War, and brought to a realization that a great world-power must have a great navy, Congress has been authorizing battle ships, cruisers, gunboats, torpedo craft, and submarines with monotonous regularity since that time.

THE "OREGON"

While the stirring times of the Spanish-American War were still fresh in mind, the battle ship *Oregon* was often named in the public press as peerless among battle ships. The development of the years immediately succeeding soon displaced this ship from the premier position. But she represents a stage in the progress of evolution from the monitor to the most modern battle ship, and her performance in the crisis of our history entitles her, for sentimental reasons, to more than passing mention.

In planning the *Oregon,* and her sister ships, the *Massachusetts* and the *Indiana,* the naval experts adhered to many of the principles that have made the monitor class of boats famous, at the same time adopting some of the features of the best foreign war vessels then in course of construction. The boats were, indeed, a compromise between the monitor and the modern battle ship as far as the general structure went, the low decks being higher than those of the monitor, but lower than those of the approved type of battle ships.

In arms, armor, and general equipment, however, they were strictly modern fighting machines.

A belt of eighteen-inch armor protected the vital parts of the hull, while seventeen-inch plates in the barbettes and fifteen-inch thickness of steel in the turrets protected the guns.

Four thirteen-inch, eight eight-inch, and four six-inch guns made up the main battery; while twenty six-pounders, six one-pounders, four Gatlings, and two field guns, with three torpedo tubes, completed the destructive armament—a total of some fifty weapons of all classes.

The *Oregon's* displacement of over ten thousand tons, and her speed of over sixteen knots, marked her as an ocean-going boat, in the ordinary sense of the term; and her wonderful voyage from California to Cuba confirmed the predictions of her designers and builders.

Her fighting qualities, which were tested on various occasions in Cuban waters, were fully up to expectations. But the modern fighting boat must be something more than a mere fighter; she must be a home for half a thousand or more men. And the low free board of the *Oregon* and her sisters was too likely to be under water too much of the time in a seaway for comfort, interfering also with the working of her guns. And so the *Oregon* type of battle ship was obsolete even before it had a chance to prove its fighting qualities in actual warfare. Indeed, one of the fighting companions of the *Oregon* before Santiago, the *Iowa,* although only two years her junior, may be taken as the

representative of the higher type of fighter. She was the first "seagoing" battle ship of the new American navy.

To the casual lay observer there is little difference between the *Iowa* type of boat and the *Oregon,* this difference being largely in the height of the fore part of the hull above the water. And in point of fact, technical differences aside, this is the main difference. There were of course scores of minor improvements in the newer boats, but this was the main point of departure from the *Oregon* type. Indeed, the *Iowa* is really a somewhat enlarged *Oregon,* with a free board some nine feet higher in the fore part of the ship, and with guns of slightly different caliber in her main turrets.

At the same time the *Oregon* and her sister ships were fighting before Santiago there were building in American shipyards two novel types of sea warriors, built on lines of purely American conception. They were the *Kentucky* and *Kearsarge,* and the arrangement of their turrets represented a distinct departure in naval architecture. In place of the turrets for the heavy guns—the twelve-inch and the eight-inch—having separate locations on the ship and acting independently, as in the case of all other battle ships in the world at that time, the four turrets of these two ships were grouped in pairs, an eight-inch turret being superimposed upon a twelve-inch. So that each turret was really a two-story steel house, through the front of which

protruded four great guns so arranged that they could be trained simultaneously upon the same spot.

The objections to this arrangement of the guns and the general structure of such a boat were that the concentration of so much weight near the ends of the boat were likely to impair her seaworthiness; that there would be serious complications in such a concentration of ammunition supply, and difficulty with the ammunition hoists placed so closely together; and that the simultaneous recoil of the four heavy guns would be too great a strain on the surrounding structures. There were also the military objections that all four guns might be disabled by a single shot, which would be impossible with turrets arranged in the ordinary manner; and that it was a doubtful policy to intrust the sighting of four great guns to a single gunner. But these objections were answered and refuted, as is proved by the fact that the boats were constructed and placed in commission. And while there has been no opportunity to test their efficiency in actual war, in practice they have proved to be all that their advocates had claimed for them.

The *Kentucky* and *Kearsarge* were the first of the American battle ships completed after the Spanish-American War. Others were building, however, such as the *Alabama* class of more than eleven thousand tons' displacement each, and these were followed by still larger vessels, some of them, the *Georgia* class, resembling the *Ken-*

tucky and *Kearsarge* in having superposed turrets, showing that this purely American method of placing the heavy guns was popular, despite active opposition in certain quarters.

When the war opened in the Far East, the United States was constructing some sea monsters of the *Connecticut* class, that are something more than half again larger than the veteran *Oregon.* They represented at that time the acme of battle-ship architecture, and may still be reckoned as formidable vessels. But in view of the lessons of the Russo-Japanese War it is not unlikely that they mark the closing of an epoch of battle-ship construction, at least as far as their armament is concerned. For this reason, therefore, some interesting comparisons may be made with the original fighting turret ship, the *Monitor,* on one hand, and the *Connecticut,* and later, between this vessel and the new English battle ship, *Dreadnought,* which established a new class, to be followed by the superdreadnoughts.

There can be no more striking evidence of the rapid advances made in battle-ship building during the last quarter of a century than a comparison between the size, armor, and armament of Ericsson's *Monitor,* probably the most powerful fighting ship in 1862, and such a battle ship as the U. S. S. *Connecticut,* one of the most powerful fighting machines of the predreadnought days.

It will be recalled that the entire fighting equipment of the *Monitor* consisted of two one-hundred-

and-fifty-pounder smooth-bore cannon carried in a single turret, the displacement of the boat being only about one thousand tons. Such figures as these seem absolutely ludicrous when compared with the size and armament of the *Connecticut.*

This leviathan of sixteen thousand tons displacement carries some sixty-two guns and four torpedo tubes. She is four hundred and fifty feet long and over seventy-six feet in beam. She carries her heaviest guns in six steel turrets, and even her relatively small guns, the seven-inch, fire projectiles weighing one hundred and sixty-five pounds, or fifteen pounds more than the guns of the *Monitor,* with a penetration of over twenty-eight inches of iron. In other words, a shot from such guns would go completely through the turret of the *Monitor,* emerging with sufficient velocity to pierce the side armor of a second monitor. The time required by such a boat to destroy completely both the *Monitor* and *Merrimac* at reasonable range would probably be reckoned in seconds, or at most in minutes, whereas the famous battle between the two boats lasted several hours without either sustaining any material damage.

The *Connecticut* has a main armor belt running from bow to stern varying from four inches in thickness at bow and stern to eleven inches at its thickest part on the middle third amidships. This armor is of the Krupp face-hardened type. The two main turrets, each containing two twelve-inch guns, are twelve inches in thickness, while

the four turrets for the eight-inch guns are eight inches in thickness.

The sixty-two guns she carries are composed of the following sizes: Four twelve-inch, eight eight-inch, twelve seven-inch, twelve three-inch rapid-fire guns, twenty-six smaller machines and automatic guns, and four submerged torpedo tubes. She can steam at the rate of eighteen knots, and her fighting complement of men is over eight hundred.

These figures contrast strikingly with such figures as those of the Civil War monitors; and it would seem that this mountain of metal must be practically invulnerable. And yet it was two similar vessels that were sent to the bottom, on the first night of the Russo-Japanese War, by Japanese torpedo boats, any one of which could have been carried on the decks of their victims without any inconvenience.

So mere size is by no means everything. Yet there are certain qualities that cannot be secured in a small vessel, nor in maximum degree even with a boat of sixteen thousand tons. And the lesson taught by the Japanese torpedo boats was not thought to be definitive; for, as we shall see, the trend of naval development in the decade following the Russo-Japanese War was strongly in the direction of increasing the size of the battle ships. We shall learn in a later chapter that within a few years of the time when the *Connecticut* was launched warships were building that were not far from double her tonnage, a full

third longer, and bearing a major battery of twelve fourteen-inch guns as against the *Connecticut's* four guns of twelve-inch caliber.

The line of reasoning that has fostered this development will be more fully revealed as we proceed.

X

THE BATTLE SHIP OF TO-DAY

THE nature of injuries sustained by the Russian battle ship *Cesarevitch* and the unarmored cruiser *Askold* in the battle of August 10th, 1904, both these ships being the center of attack by a superior number of Japanese boats of their own class for several hours, are most interesting.

But perhaps the most significant fact, as well as the most interesting, is that they escaped, and finally made their ways to neutral ports. "Considering the length of time that the engagement in its various phases lasted," says a naval writer, "and the vivacity of the fire directed at the Russian ships, it is truly astonishing that they were not hit more often." And this opinion must be shared by every thoughtful person, taught to regard modern gunnery as almost an exact science.

The *Cesarevitch,* whose ultimate fate is told in another chapter, was a good representative of the high-class modern battle ship. During the battle she was hit some fifteen times by twelve-inch projectiles, and a much greater number of times by smaller ones. The effect of these smaller projectiles was so slight that they need not be considered here; but the position and effects of

the heavier ones are instructive. The armor of each turret was hit once, and not damaged.

Three shells struck and injured the funnels, interfering with the steaming of the vessel to a certain extent. One struck the side of the ship below the position of a turret, tore a hole three and one-half feet square in the side plating, but did little damage. Another pierced the vessel near the bow on a level with the upper deck, making a large hole, but otherwise producing no effect. One shell destroyed the foremost chart house; another tore the railing from the upper deck, shattering the planking of the deck, but not setting it on fire. The roof of one turret was struck by a shell close to the sighting hood. The hood was slightly bulged, the man inside stunned for a few minutes, and a man inside the turret killed by a flying rivet loosened by the impact.

One shell struck the ship six feet below the water line, bending plates and frames, but not tearing or injuring them severely, although some one hundred and fifty tons of water was admitted into a compartment.

The conning tower was struck, and five men in it killed and two wounded. Another shot struck the foot of the foremast, damaging it severely, killing Rear-Admiral Vithoft, and killing and wounding eighteen other officers and men. Two other shells splintered some boats and deck timbers, but did trifling damage.

It is apparent, therefore, that the Japanese shells did relatively little damage.

" In spite of the wooden decks and of all the boats being inboard, the effect of splinters was very small, and the wooden decks were not set on fire. Fragments of shell fell down the after funnel and damaged some of the superheated tubes. The effect of the gases from the bursting of the high-explosive shells was serious. Many men who had received no direct wound suffered twenty-four hours after the action from stupor, giddiness, loss of memory, and headache. The hair, beard, and sometimes the skin of those who were near such a shell when it burst were stained a deep yellow. The same coloring effect was also noticed on the parts of the ship near which the bursting occurred. The *Cesarevitch* fired seventy-four or seventy-five rounds from her fore turret, forty to forty-five rounds from her after turret, and from five hundred and eighty to six hundred from the six-inch guns."

It is evident that most of the shots fired passed over the vessel, and from this the conclusion may be drawn that if the *Cesarevitch* had been a monitor type of boat, with scarcely anything but turrets and funnels above the water line, she would have escaped practically unscathed. This at once raises the question as to whether the monitors are not even now the most formidable boats afloat, under certain conditions; and there seems little doubt that in calm waters, such as those of harbors and harbor entrances, they are most dangerous fighting craft. It is to be noted that in the contest between the Germans and the Allies

along the Belgian coast in October, 1914, British monitors came in close to the shore and shelled the German land batteries effectively.

Even more astonishing than the escape of the battle ship *Cesarevitch* in the battle of August 10th was that of the unarmored cruiser *Askold,* which was exposed for some time to the concentrated fire of no less than seven Japanese ships, most of them unarmored cruisers like herself, but one, at least, an armored vessel. In the earlier part of the action the *Askold* had been hit twice, first by a twelve-inch shell, which burst above the deck near the foremost funnel, killing an officer who was working the range finder on the bridge. This shell also tore some plates off the funnel, so that two boilers were eventually put out of commission. The other shell, ricochetting off the water, landed in some ammunition for the three-inch guns and exploded some of it, but did no further damage.

Later in the fight the *Askold* broke through the Japanese fleet, drawing the fire of the seven vessels just referred to. Fourteen large projectiles, and a great number of small ones, struck her. Two of her five funnels were shot away, her boats were riddled, and her hull pierced. An eight-inch shell struck her exactly on the water line, tore a hole two feet and a half square in the outer skin, but did no other damage. Three other eight-inch shells made holes in her sides and wrecked officers' cabins, yet her fighting ability was scarcely impaired at all; and she is believed to have put out

of action the Japanese cruiser *Yakumo* before she outran the fleet and made her way to Shanghai.

Thus the unarmored *Askold,* receiving practically the same punishment as the heavily armored *Cesarevitch,* was also able to shake off her pursuers and escape.

This feat called for the serious consideration of naval constructors all over the world. It raised the question as to whether the fighting ship is to be a " fort " or a " weapon "—an invulnerable wall of steel, constructed at the sacrifice of speed and projectile-throwing power, or a less protected but faster and more powerfully armed fighting machine.

But the great lesson of the Russo-Japanese War on the sea was to be learned from the final struggle which was to be recorded in history as the battle of the Sea of Japan. From this battle, more than all the other engagements of the war, the value of modern fighting craft and fighting methods was to be learned. Old theories were to be confirmed, new ones developed, and, curiously enough, very few recent ones overthrown.

First of all, the old, old principle of the value of experience was to be demonstrated again, as it has been so often before. In the previous battles, as we have seen, the Japanese gunnery was surprisingly bad. Boats made their escape through their lines of battle at a range at which they should have been blown to pieces. But on the day of the battle of the Sea of Japan this was not repeated. The little Japanese gunners were now

veterans. Firing, if anything, more deliberately than in previous battles, their marksmanship was far better than ever before, completely outclassing their novice opponents, putting ship after ship out of commission with methodical regularity.

Six months before they were not able to do this; but now they had learned their trade.

" Of bravery," says a Japanese officer, in speaking of the comparison between the two opposing fleets, " there was no difference on either side." But bravery without experience avails little against bravery plus experience.

And had the inexperienced Russian fleet been twice its size it is probable that the story of defeat would have been the same. For it seems to be as true in fighting on the ocean with a fleet of vessels as it is in individual combats of any kind that experience is largely the determining factor.

A well-known pugilist, being told of the fighting prowess of an aspiring young giant much larger and stronger than himself, asked the simple question: " How long has he been in this fighting game? "

" About a year," someone told him.

" Then I can beat him," said the veteran. " I can beat any man who has only been in the business that length of time, no matter how big or how strong he is. He hasn't had time to learn his trade." And a few weeks later he demonstrated the truth of his statement.

And so at the battle of the Sea of Japan the veteran fighters beat down their novice opponents,

dealing them blow after blow, and receiving little injury in return. Eight Russian battle ships entered the fight. Of these, three were sunk by gun fire, two surrendered, and three were torpedoed in the night, after being severely battered. Of the three coast-defense ships, one was sunk by gun fire and two were captured. The three armored cruisers were torpedoed in the night. Three of the four lighter cruisers escaped, the fourth being sunk by fire. Of the seven destroyers, four were sunk, one was captured, and two escaped.

But the notable thing of this engagement was the rapidity with which the Japanese gunners struck down their opponents. Ammunition was wasted, of course, as it must always be, but to no such extent as in the preceding battles, notably that of August 10th.

Of the other things demonstrated by this great sea battle it may be said that there were few surprises for naval men, but rather a confirmation of their theories. It was shown conclusively that speed is an important quality of a fighting ship; and it was shown also that large battle ships, equipped with many large guns, would be superior to the ordinary type, with a few heavy guns, a few more of intermediate size (such as the eight-inch guns), still more of the five- and six-inch sizes, and a great number of smaller rapid-fire guns.

Indeed, the effect of this battle was to discredit the intermediate type of guns on battle ships.

Some remarks on our navy and the lessons of this battle were made not long after the event

by Captain Richard Wainwright, of the United States Navy, which are peculiarly interesting, as coming from a veteran of the Spanish-American War, who distinguished himself as commander of the spectacular little *Gloucester* at the battle of Santiago.

"The displacement of our battle ships," says Captain Wainwright, "like those of other naval powers, has been steadily increasing, and increased displacement has many logical opponents, for sometimes the increased size has brought greater cost without commensurate increase in power. Neglecting the *Maine* and *Texas*, as they were experiments and not over-successful ones, our first type of battle ship was of ten thousand tons, and this has been increased to thirteen and now to sixteen thousand tons (a few years later to about thirty thousand). The first type, the *Indiana* class, carried four heavy guns, and the latest type carry the same number. Now there have been many improvements in guns, armor, and equipments that make the latest type much stronger than the first, but we are considering increase in size only."

The first increase in size gave a large increase in the intermediate battery power; but there are not many who now believe that the gain in power of a *Connecticut* over a modern ship of similar design to the *Iowa* is sufficient to pay for increased cost of construction and maintenance. Many have claimed that more units were better than a few large vessels, and this claim was not difficult to

sustain when the small battle ship carried the same number of guns as the large ones.

"The introduction of the intermediate battery was logical, as at the time it was developed the primary battery guns were very slow in firing and extremely slow in hitting. With insecure sights and brown powder, turrets were not instruments of precision. As there were large areas of the ships that were either lightly armored or unarmored, the intermediate rapid-fire guns were introduced, for they had sufficient power to injure the personnel and even to diminish, to a large degree, the efficiency of the ship by the destruction of soft ends. Then came more light armor to protect the intermediate battery, with the necessary increase in displacement.

"Since we have been developing larger battle ships, the power of hitting with the big guns has been increasing by leaps and bounds. All ordnance material has improved and the training of officers and men has become scientific. Now the heaviest guns can be fired as rapidly as the intermediate guns could be fired formerly, and with them they make more hits than the lighter guns could make in earlier times. The old theories of a 'smothering fire' and 'a greater number of units' must be allowed to die; as one or two hits from the big guns can destroy soft ends and wreck weak battery spaces, and such guns only are able to attack the life of the ship. Look at the *Orel!* What use is there in having a large intermediate battery if its power is destroyed

before the ship can come into effective range of the lighter guns?"

The last sentence shows the attitude of the naval experts towards the equipment of the battle ship, and their views have been substantiated in actual battle in the Far East. The argument must appeal to anyone. If a battle ship, keeping out of range of the smaller guns of her enemy, had the advantage of two to one in her heavy long-range guns, it is obvious that she can deliver two shots of heavy metal to her opponent's one.

In such a case, no matter how superior the intermediate and secondary batteries of her enemy, she might be able to keep her advantage and finally decide the issue simply by keeping at long range.

This view was held before the Russo-Japanese War, and the actions of that war showed that the view was correct. How impressive the lessons of the war have been is shown by the action of the British Admiralty as soon as the war closed. Holding the advantage of all other neutral powers by having representatives on some of the Japanese boats, observing the various features of the battles, this body had been so impressed with the reports of these representatives as to the advantage of the proposed new type of battle ship that the plans for such a boat, to be called the *Dreadnought,* were drawn at once, and the vessel was soon under construction.

A report published in the New York *Tribune* at the time of the launching of this great ship

Part of the Gun Crew of the U. S. S. "Wyoming"

(1906) gives some idea of the novel features of her construction and what was expected of her as a fighting craft.

DREADNOUGHTS AND SUPERDREADNOUGHTS

"The launch of the *Dreadnought,* in the largest and most powerful of the world's navies, marks the first stage in what the British Admiralty says is the greatest achievement in naval construction. On October 2, 1905, work was begun at Portsmouth on the vessel, the first of what is to be known as the *Dreadnought* class. The promise was made then that she would be launched within six months. The Admiralty has more than made good the boast, and the British have another cause for pride in their navy.

"There are two reasons why work is being rushed on the *Dreadnought.* One is the great saving in cost, but the chief reason is that the ship is to some extent an experiment, and it is desired to give her a careful trial before beginning construction on any more of her class. Great Britain, it will be remembered, was the only power having attachés or observers on Japanese boats in the Russo-Japanese War, while expert British constructors had every opportunity of learning wherein the ships of Japan proved weak or strong. These men were busy from start to finish of the war, and immediately after the battle of the Sea of Japan came home with their data, which were submitted with suggestions to a special committee

on which sat not only the most experienced naval experts, but the director of naval construction, Lord Kelvin, and a number of the leading private shipbuilders.

"The *Dreadnought* is the outcome of their deliberations, an embodiment of the lessons of the recent war in the Far East, a ship apparently invincible, capable at one discharge of her guns of throwing twice as much metal as any foreign warship now afloat, while her armor is expected to render her safe from attacks of any enemy's guns, and some say even from torpedoes, fired at the usual battle range. The details of the *Dreadnought's* construction remain a secret, so well has the Admiralty guarded the plans. Efforts of naval attachés to gather information for their governments have been fruitless. The answer to all inquiries is the candid one that Great Britain intends to maintain secrecy in regard to what her experts learned as the result of Japan's experiences for one year. By rushing to completion the *Dreadnought* England will gain a year, if not more, in naval construction over all other powers except her ally. Usually, when ships are building, a board is placed at the head of the ship, giving her name, displacement, principal dimensions, horse power, and speed. In the case of the *Dreadnought,* not an item in the design is revealed, the board containing the single sentence: 'His Majesty's ship *Dreadnought,* commenced October 2nd, 1905.'

"When ready for sea the ship will displace

eighteen thousand five hundred tons, but this is the least remarkable thing about her, for, besides the ideas introduced as a result of the Far Eastern war, Britain is placing on her new fighting machine the heaviest armament ever carried by a ship. Former British battle ships have carried four twelve-inch guns, throwing eight-hundred-and-fifty-pound shells. The *Dreadnought* will have ten of these weapons, with a muzzle energy of forty-nine thousand five hundred and sixty-eight, as compared with the thirty-three thousand six hundred and twenty-two of the guns carried in as recent battle ships as the *Majestic* class. The *Dreadnought* will be able to discharge ten projectiles weighing eight thousand five hundred pounds with sufficient velocity to send them twenty-five miles. Unlike all British and foreign battle ships built in the last thirty years, the new addition to the fleet will carry no weapon smaller than the great twelve-inch piece, except eighteen three-inch quick-firers for repelling the attacks of torpedo craft. She will not mount nine-and-two-tenths-inch, seven-and-two-tenths-inch, or six-inch guns; she will be the biggest warship afloat, and she will have only the biggest and most powerful guns.

"The secrets which will be incorporated in the huge hull are still hidden, but it is known that they tend to economy as well as efficiency. The *Dreadnought* will cost ten per cent. less than recent battle ships of British build, although she will represent the last word in all details of her construc-

tion. She will be the first battle ship in the world to be driven by turbines. These engines will supply the power for four propellers, two more than any previously built British battle ship, which should make her the fastest ship of her class afloat. Another advantage of the turbines, as shown by the performances of the *Carmania,* is that the gunners will have a steadier deck from which to handle the guns.

"Writing of the fleet as it will be when the *Dreadnought* joins it, a naval expert said recently: 'Nothing as devastating as this concentrated destruction has ever been conceived in the brain of man. It is impossible to picture the result of one minute's well-directed fire at an enemy's ships, and when one minute is followed by others, the effect would be too terrible for words, presuming the gunners get the range and fire as at target practice. To this length has the contest for sea power gone, and this is not the end, for the time is not far distant when the British ensign will fly over fleets and squadrons of dreadnoughts, vessels costing a million and a half sterling or more, each with ten or twelve twelve-inch guns, which will engage an antagonist when three or four miles distant, and will pour a succession of shells, each weighing eight hundred and fifty pounds and carrying wholesale destruction in its wake.'"

To those familiar with the battle records of the Far East, this last note of alarm as to the terrible destruction of life likely to be effected by this

new fighting machine will not be taken too seriously, but rather in a relative sense. The same thing has been said of practically every new type of war vessel devised in recent years; yet the battle of the Sea of Japan was no more sanguinary than Trafalgar or the battle of the Nile. Defensive methods always keep pace more or less with offensive.

It was evident, however, that England had stolen a march on all other naval powers and had now the most wonderful fighting machine afloat. But other nations quickly followed the lead. The United States, for example, soon authorized the building of two battle ships on very much the same lines as the *Dreadnought,* namely, the *Michigan* and the *South Carolina;* each of sixteen thousand tons, equipped with eight twelve-inch guns. These were completed in 1909. There followed three others, the *North Dakota,* the *Delaware,* and the *Florida;* the first two of twenty thousand tons each, the other of twenty-one thousand eight hundred and twenty-five tons, each having a major battery of ten twelve-inch guns.

And so well pleased were the authorities with these vessels of dreadnought type that, still following the example of England, plans were at once under consideration for the construction of yet larger battle ships, which came to be known as superdreadnoughts.

The American vessels of this type include the *New York* and the *Texas,* with displacement of twenty-seven thousand tons, with batteries of ten

fourteen-inch and twenty-two five-inch guns; followed by the *Nevada* and *Oklahoma,* with estimated tonnage not far from thirty thousand, and designed to carry twelve fourteen-inch guns—ships five hundred and seventy-five feet in length and one of them of ninety-five-foot beam; and the *Pennsylvania,* six hundred feet in length and of ninety-seven foot beam, and a draught of twenty-eight feet ten inches.

Such is the superdreadnought, a type of sea monster with which the chief navies of the world were soon equipped. By comparison, they make the largest warships of a single decade before seem but feeble craft.

Nor is there any possibility that even these steel leviathans represent finality in the type of battle ship. No type of boat has been considered supreme for more than five years at any period during the last thirty years of naval progress. Yet the time must come inevitably when either some general size, form, and armament will be found to be the nearest approach to the ideal for battle ships, or else that the type must change entirely. It seems highly improbable that the size of warships will continue to increase as rapidly for the next twenty years as they have during the last; yet it is by no means certain that they will not. There seems to be practically no limit to the size of merchant vessels, and the same thing may apply to fighting craft.

A thing that is more likely to check the building of the great vessels is the development of some

other fighting machine that will make it undesirable to "put too many eggs into one basket," as the naval men express it. Some perfected submersible might change the present tendency for building larger and larger battle ships; or some perfected torpedo, aërial, or submarine, some wonderful armor-piercing projectile, or one of a dozen now unsuspected things, may produce the same effect. Sooner or later this must come, of course, for there is no such thing as stasis in naval affairs.

We cannot hope to gain much insight into the possibilities of the future of modern vessels by looking at their histories in the past, since the difference in the boats themselves and their equipment is so great; yet if there is any lesson to be learned from such a study, it is that the great ocean battle monster will be supplanted. The Greeks increased the size of their fighting boats until they were huge barges, having tiers of rowers—forty of such tiers sometimes, we are told. Yet a change in methods of sea fighting by the Romans eventually made such huge boats all but useless. Again in the Middle Ages the change of the shape of oars, putting more than one man to each oar, revolutionized the shape of sea fighters; and later the coming of gunpowder revived the many-decked boat, the decks now being occupied with cannon instead of oarsmen. Deck upon deck was added to these new fighting ships, until they were veritable "skyscrapers" in the nautical world.

Then the steam engine was invented, speed became a desideratum, and again the lower type of boat became popular. These were assuming huge proportions, however, when the little *Monitor,* small enough almost to be carried on the deck of some of the great wooden boats, in a single day made them an obsolete type.

And so it may be that the superdreadnoughts will prove to be the last of a quickly developed type; and even before the newest vessels of the type are ready for sea they may belong to an obsolete class. The performance of the peculiar-shaped *Monitor,* it will be recalled, stopped the work on a great number of vessels then on the way in the foreign shipyards, as the types under construction were shown to be obsolescent; and at any time this same thing may be repeated. The early developments of the great war in Europe in the autumn of 1914 suggest that the submarine, rather than the battle ship, may claim chief attention of the naval experts of the coming decade. But any forecast based on these events must be held as strictly tentative. The crippling of the superdreadnought *Audacious* proved that these vessels are vulnerable below the water line; but their destructive capacity is unquestionably enormous, and it may readily chance that in an open sea fight they would give an account of themselves fully justifying the confidence reposed in them by their builders.

XI

GRAPPLING WITH DISEASE

IT is pretty generally understood that bullets are by no means the most dangerous enemies of an army. The records show that in most wars during the past century only about one man in fifty died from gunshot wounds. Yet the total number of deaths reached the proportion of one in ten, on an average. Obviously, then, there is some enemy of the soldier at least four times more dangerous than his human antagonists. And any veteran, even of a single campaign, understands that his enemy—one that has decided many important campaigns in history—is disease.

Yet, paradoxical as it may seem to those unfamiliar with the difficulties of a campaign, the maladies responsible for the greatest number of deaths among soldiers are those known to physicians as " preventable " diseases.

Even if all these things were generally known, it is probable that in the excitement of impending war there would be the same rush of patriotic volunteers to join the colors against an enemy. Yet there would be a natural revulsion on the part of the soldier in feeling that his chances of dying ingloriously in a hospital of some loathsome disease instead of on the battlefield were

fully four to one. He would not choose such a death of his own volition. It is unjust, but nevertheless true, that the simple epitaph, " Died while defending his country," conveys the meaning of a much more glorious death when there is added " in battle," instead of " of disease." And the time is at hand when, knowing as we do now the cause of most diseases and the simple methods of preventing them, the soldier and his friends who remain behind will not observe with equanimity or tolerate the record of disease ravage that has made war more than doubly terrible in the past.

Disease has been the deciding factor in many of the great campaigns in history, whether those of a Pharaoh in Egypt, a Hannibal, or a Napoleon. It will be recalled that the army of the Assyrian, when he "came down like a wolf on the fold," was stricken by the " angel of God " and decimated: in short, his army was so afflicted by disease that he was obliged to raise the siege for want of fighting men. And succeeding centuries have witnessed similar disasters.

In modern times cases are recorded where regiments were exterminated before they could reach the seat of war. This is said, on good authority, to have happened in the Crimean War, when in one campaign of six months it is estimated that, in a loss of fifty thousand men, only two thousand died from bullets.

Even more shocking than this record is that of the French in the Madagascar campaign of

1894, where, out of fourteen thousand men in the field, seven thousand died of disease, while only twenty-nine were killed in battle.

In the Civil War a little less than the proportion of four to one died from disease, as against those killed in battle; while in the Franco-Prussian War the Germans, probably for the first time in the history of warfare, made the remarkable record of having fewer, by half, die from disease than by bullets. Meanwhile the French were being weakened day by day by the ravages of the archenemy.

When the Spanish-American War broke out, our own progressive country was so ill prepared with modern equipment for combating disease that at the end of a hundred days—about six weeks of actual fighting—some three hundred men had been killed, and about four thousand had died of disease, or a proportion of about fourteen to one. The West had not profited by experience.

Then came the Russo-Japanese War, in which the Oriental armies lost but one man from disease to every four killed on the firing line—an absolutely unprecedented record.

And yet all that Japan knew of the methods of preventing disease she had learned from Western nations. She made no discoveries of new things or methods that were not the common knowledge of every physician, and of thousands of laymen. She simply put into practice what the West had taught her.

From this record of the Japanese army it will

be seen that the so-called "preventable" diseases are really preventable: that the medical man was not dreaming the dreams of the visionary when he asserted that most cases of malaria, dysentery, smallpox, and above all, typhoid—the bane of every army—could be prevented even in large armies.

There are, to be sure, a number of diseases that cannot be prevented, any more than can such cases in civil life; but about eighty per cent. of all diseases that affect the modern army are among those mentioned and properly classed as preventable ones.

The two great causes of sickness in an army, aside from wounds, are improper diet and infection by disease germs. Frequently the first of these makes it possible for the other to gain a foothold, so that the improperly fed man is not only subject to diseases that are the direct outcome of his improper diet, but is also rendered susceptible to the disease germ. But so long as there was no means of supplying armies and navies with proper forms of nourishment, as was the case until recent times, these things were inevitable.

Thus before the days of canned goods, when the preservation of perishables was not well understood, it was a foregone conclusion that cases of scurvy would develop among the members of the crews of ships making long voyages. But since it has become known that this disease is caused solely by defects of diet, and now that vegetables

of every description can be kept in a canned state indefinitely, scurvy has become a rare disease.

A more striking example of what may be accomplished by proper diet is that of the stamping out of beriberi in the Japanese navy. For a long time the Japanese scientists had been convinced that this disease in their armies and navy was due to the large quantities of rice eaten by the men, to the exclusion of other forms of food. They based their beliefs on observation as well as on well-established physiological facts. They observed, for example, that no cases of beriberi developed among the crews of foreign vessels stationed for years in Oriental waters, and the only perceptible difference in the treatment of these crews from those on their own boats was in the matter of diet.

It was subsequently discovered that beriberi results from the absence of a substance now known as vitamine, which is found in the husk of the rice, and which is removed with the husk when the rice is polished. It was not the rice diet, but the use of rice "improved" by polishing, that was responsible for the disease.

The very life of the Japanese nation seemed to depend upon the efficiency of its navy; and yet, in 1882, when there was a war cloud hanging over the Far East and Japan seemed likely to be drawn into a struggle with Korea, five of the Mikado's largest war vessels were all but useless, owing to the fact that such a large percentage of their crews were sick with beriberi.

At this time the Deputy Medical Inspector General of the navy was Doctor Takaki—the " Jenner " of the Japanese world. He had studied the subject of beriberi carefully and had reached some very definite conclusions as to its cause, but as yet had had no way of thoroughly testing his theories. But his chance came in 1883, after a protracted cruise of the warship *Ryujo,* lasting two hundred and seventy-one days, during which over a hundred cases of the disease developed among a crew of three hundred and fifty persons.

When the facts of this voyage became known, Dr. Takaki asked the Minister of Marine that another similar vessel be sent over the same course at the same time of year, the regular ration of the crew being changed to one selected by Takaki. Fully alive to the importance of stamping out the disease, and having great confidence in his medical officer, the Minister consented, and the *Taukuba* was detailed to make the voyage.

Starting at the corresponding time of the year, and making the same stops and in practically the same time as the *Ryujo,* the *Taukuba* completed the voyage without any serious cases of the disease developing, sixteen mild cases, all told, being reported, as against one hundred and sixty cases the year before on the *Ryujo.*

This was a demonstration that admitted of no appeal as to the cause of the disease that had scourged the Orient for so long. A new dietary was adopted at once in the navy, cases of beriberi became more and more rare, until, by 1887, the

disease had disappeared, despite the constant increase in the number of men in the fighting force.

During the Russo-Japanese War the full complement of able-bodied fighting men was kept practically at one hundred per cent., so far as this disease was concerned.

In view of these demonstrations one would naturally suppose that the progressive Japanese army, the peer of any army in the world, and conspicuous for its readiness to adopt useful innovations, would have followed the lead of the navy and changed the diet so as to wipe out this disease. But in point of fact beriberi was the cause of almost one-half of the cases of sickness in the army during the Russo-Japanese War. The army had adhered to the old diet, despite the conclusive demonstration in the navy, and although a tardy change in the ration was made towards the close of the war, the change came too late to save the one stain that can never be erased from the otherwise clean and unparalleled record of the army surgeons of the Mikado.

But scurvy and beriberi, the results of improper diet, are about the only diseases known to be directly traceable to the continued use of improper food. There are others, however, such as the numerous germ-produced intestinal troubles, that are indirectly induced by the foods themselves, the germ finding easy entrance to a system improperly fed.

In Western nations, where scurvy has disappeared, and where beriberi does not exist, these

are the diseases accountable for the high mortality of the armies.

As every one knows, the so-called germs are microscopic plants which, when taken into the system under proper conditions, multiply and produce diseases. The two great avenues of entrance are the respiratory and digestive tracts. There is also the important source, the skin, through which the disease germs may enter the system either through abrasions or by the action of certain insects, such as flies and mosquitoes. If the soldier can escape contamination from these few sources he incurs relatively little danger of being sick on the campaign.

Like all other forms of vegetable life, germs are killed or rendered inert by heating to the boiling point for a few moments; and they succumb to certain chemicals known as "antiseptics." The simple process of cooking or boiling, therefore, suffices to guard against the action of disease germs found in water or in food. Cholera, typhoid, and dysentery may thus be prevented, typhoid being the most fatal of these to modern armies, and its germ the one with which drinking water is most likely to be contaminated.

The wells along the line of march of the ordinary army are responsible for more deaths than the enemy's bullets. Yet theoretically this should not be so if the soldier is aware that the wells may be germ-poisoned, or that he can purify their water by boiling it. And in practice the Japanese have shown that this theory is correct. The record

The Automobile in Modern Warfare

An automobile truck hauling a field gun and its equipment in France

of four men killed to every one that died of disease in the Russo-Japanese War evidences what the scientist in the laboratory has done in the last quarter of a century to ameliorate the condition of the fighting soldier.

Equipped with this knowledge of the cause and means of prevention of the diseases most common to troops in the field, it would seem that every modern army should be able to eliminate the great factor of sickness in the ranks and keep a far higher percentage of men fit for the firing line all through the campaign. But Japan was the first country that succeeded in putting into practice what had been known theoretically for a considerable time. The United States did not do so in her war with Spain; England failed almost as signally in the later war with the Boers; and Russia was probably even less fortunate in her last war, while her opponents were astonishing the world. England, America, and Russia all knew as much about scientific hygiene as Japan —had, indeed, taught her all she knew of the subject. Why, then, this failure on their part? The answer is simply that they did not get around to do what they were fully aware should be done. Perhaps if they had known that a war was inevitable, and had known it for ten years, as Japan knew in the case of the approaching war with Russia, other nations would have duplicated her remarkable record in the Far East.

Be that as it may, Japan, seeing the inevitable war cloud looming larger and blacker, laid her

plans to carry on a strictly scientific campaign. First of all she showed her faith in her medical men by arming them with authority; and then, after instructing her men to obey them implicitly, she explained to the men in a simple but convincing manner the reason for this obedience. She told them why they should not drink at every well and pool of water; why they should cook certain foods and should avoid others altogether; and what they should do in a general way to avoid all manner of diseases. The remarkable thing is, not that the men believed what they were told, but that they obeyed. The little books of instructions issued to the soldiers contain some simple facts and suggestions that could be read profitably by any person, soldier or civilian, in any walk of life.

" Infectious diseases are caused by the poison getting into the body from the outside, which can be prevented by proper care," says this little book. " These diseases are caused by microscopical objects called germs. In former times the number of deaths from these diseases exceeded the number of those killed in battle. Therefore, never neglect to exercise the utmost caution against these germs.

" The infectious disease that is almost always present with an army is typhoid fever. This is caused from germs in food or drink. Therefore the first step in preventing it is not to eat raw things and not to drink unboiled water.

" The means of preventing dysentery and cholera are almost the same as those for prevent-

ing typhoid fever. Unripened fruit is apt to produce diarrhea, therefore be very careful of that.

"Plague generally comes through injuries to the skin. Therefore even a little wound should be examined by a physician. Never walk with bare feet, as rats and fleas spread this disease: kill them or drive them away.

"Malaria is spread by mosquitoes, therefore protect yourself from them as much as possible."

There were also instructions and hints as to keeping the body in the best possible condition to resist disease. Bathing was especially enjoined; and when this was found impossible at frequent intervals, the men were instructed to rub every part of the body with a dry towel at least once a day. They were instructed to keep the hair cut short and wash the head frequently, and great emphasis was laid on the importance of keeping the hands and feet in the best possible condition, care of the finger nails being especially enjoined. In the matter of dress, elaborate instructions were given, including the care of clothing and shoes, and reasons that would appeal to the soldier were given for all these things.

For example, the saying of a famous commander was quoted, to the effect that the key to the success of an army lies in the condition of the feet.

The soldiers were instructed never to expose the head to the direct sunshine, and never to sleep on damp ground if it was possible to get branches of straw to cover it. They were warned against

drinking too frequently or too freely on the march, and were given such useful hints as that of holding a plum or a straw or leaf in the mouth when no water was available. In a word, they were instructed in the common-sense rules of hygiene which science has evolved. All this was a direct help to the soldier, and so indirectly an aid to the medical officer. In return these officers used every effort to make it possible for the men to carry out the instructions.

One of the most radical innovations introduced by the Japanese was the placing of medical officers in the van of the army.

The place for the surgeons since time immemorial has been at the rear. But the modern idea of prevention rather than cure has been making its way in the armies as well as among bodies of civilians, and the surgeon has gradually found his way to the front of the army, except at the actual time of the engagement. The Japanese used a cloud of doctors for " skirmishers," just as they did the cloud of fighting men—skirmisher doctors who examined wells and streams in advance of the troops, and who set up signs regarding the potability of the water in each. Every scouting or foraging detachment was accompanied by a medical officer equipped with a water-testing outfit. This was carried in a canvas case and contained the proper chemicals for making rough but conclusive tests.

The drinking places were labeled in three ways, according to the result of the tests: " Pure drink-

ing water "; " Filter and boil before drinking "; " Use for washing only; not drinking." And the mandates of these signs were rigorously followed by the soldiers.

As an adjunct to the corps of field testers were corps of microscopists—" the most deadly foe to the Russian cause," as some one has said, since it deprived them of the aid of disease, that heretofore has been the greatest aid to an opposing force. These microscopists could not accompany the hurrying bodies of scouts and skirmishers, as in the case of the chemical testers; but they could follow more slowly, making exhaustive confirmatory tests, and so clinching the work of their predecessors in the field. It was the duty of these physicians to attend to the improvement of the sanitary conditions of a town where a halt was made for more than twenty-four hours, and their word was law. The sanitary squad in such cases made a careful inspection of every building in the town, ordering those cleaned that proved to be in reasonably good condition, and destroying those that were near the danger line of possible infection.

The result was that, instead of the towns occupied by the advancing armies becoming filthy, infectious disease breeders, as has been the rule with invading armies heretofore, the towns occupied by the Japanese became clean and sanitary —most of them for the first time in their histories.

Cleaning alone did not suffice to protect the troops from possible sources of infection. Foods sold by natives had to pass a rigorous examina-

tion by the medical staff, and if condemned were destroyed. There were also rules laid down for regulating the manner in which certain perishable articles should be offered for sale, such as the rule that all articles offered publicly must be protected from flies. Indeed, the war waged by the surgeons against flies and mosquitoes was quite as persistent and relentless as that against the germs. Specially constructed fly traps were put in use everywhere; and mosquito netting and other means of keeping off these malaria-bearers were used as never before in the history of warfare. All these preventive measures helped to hold the dreaded diseases in check.

THE TRIUMPH OF MODERN SURGERY

The triumph of sanitary science seems the more complete because so very generally unexpected.

In point of fact it was no more remarkable than the other analogous triumph of science, the saving of life among the wounded. But the world has become accustomed to expect the miraculous in surgery, or anything pertaining to the art; so that there was less surprise at the record made by the Japanese of losing only one and one-half per cent. of their army from gunshot wounds, although twenty-four per cent. were wounded.

The scientific knowledge responsible for this remarkable record is, of course, the same as that which governs the sanitary department—the knowledge that germs are largely the cause of dis-

eases, whether they be in the form of infectious maladies or infected wounds. In either case, the underlying principle of combating them is the same, the principle of prevention. And this prevention consists essentially in keeping the germ out of the wound. The dressing of the wound and subsequent operations, when necessary, may be deferred almost indefinitely if the poisonous germ can be excluded from the fresh wound.

Here again the intelligent aid of the fighting man was requisitioned by the surgeon. Every man was instructed in the causes of diseases in wounds just as in the case of the matter of sanitary precautions. He was also instructed as to what he should do in case he was wounded, and was furnished with a "first aid" package with which to carry out these instructions.

First of all, he was to see that his body was clean before going into battle, and if possible to put on clean clothing so as to lessen the danger of infection from unclean shreds coming in contact with wounds.

If struck by a bullet, he was to tear open his first-aid package at once, apply the dressing and bandage as he had been instructed to do, and either make his way to the rear or wait for the stretcher men to find him and carry him to the hospital in the rear of the firing line.

Had the men been ignorant of the proper method of caring for their wounds, or had they followed the custom of soldiers of a quarter of a century ago of either leaving the wounds alone,

or of dressing them with strips of germ-laden clothing, handkerchiefs, etc., the mortality from wounds would have been much the same as in previous wars, and the work of the surgeons greatly increased.

As it was, the surgeons found themselves free to concentrate their efforts in caring for the desperate cases, knowing that the "first-aid" dressings on the minor injuries would suffice for the time being. Indeed, it happened in thousands of cases that these dressings were not disturbed by the surgeons after the men had applied them, the healing process taking place quite as readily as if the dressing had been applied by the most skillful surgeon.

On the battle ships first-aid packages were scattered about everywhere, so that there would be no shortage in any part of the vessel. The men bathed and put on clean clothing before an expected battle, and were told to apply first-aid bandages at once the same as the soldiers. For although the surgeons are always close at hand on a battle ship, the bursting of a single shell frequently injures so many men that some of the less severely injured must wait for the surgeons; and it is in these cases that the first-aid dressings are most useful. So that the problem of caring for the wounded in a naval battle does not differ essentially from that of caring for the wounded in land battles.

In this connection some notes on the Japanese method of attending to the wounded, by Dr.

Tamura, of the Japanese army, are of peculiar interest:

"We do not use much in the way of antiseptics in first treatment," he says. "Each soldier carries a little bag of first-aid containing antiseptic compresses and bandages, and the soldier, if wounded, applies first the compress and then the bandage. If this is not enough, then he must go back to the surgeon for more extensive treatment.

"In the hospitals it is a larger question, and there we apply modern methods, but we have developed nothing new in practical methods of securing asepsis in wounds. The use of iodoform is not to apply it directly, but to put cotton cloth over the wound first. A direct application stimulates too much. Prior to this war, a first-aid dressing was prepared from ashes of straw, which were placed in a little bag and pressed over the wound. It was invented by Dr. Kikuchi. The effect was to dry the wound quickly, and it had also an antiseptic effect.

"Our soldiers are trained in peace to use first-aid dressings and habitually apply them very intelligently, assisted in the worst cases by their comrades. The care with which they are applied is very noticeable, and in case of slight wounds, and to some extent with severe wounds, this finishes the treatment.

"In such cases, where the dressing has been carefully done and the bandage does not become too much soiled, it is better to leave it without change. So you see the first dressing is very

important. If it is badly done, redressing becomes necessary, and in this way sometimes the wound gets worse. When the wound is larger, such as is made by shells, necessitating measures to stop the flow of blood, or bones have been fractured, the case is different. In these cases the first-aid dressing is of the greatest importance, and is customarily applied on the field by the surgeon with the troops.

"While I have no doubt that many practical methods have been developed, in our extensive experience in this war, of caring for the wounded, none have been reported as yet; in fact, few reports of this character have been received."

This last sentence contains food for thought for all Western nations. Confessedly the great triumph of medical science in this war by Japan—the most conspicuous triumph, and the only one unprecedented—is simply a careful application of the things known to every Western nation. Nothing new has been discovered: every medical man in Europe and America knows all the things known to the Japanese as regards medicine and surgery. But no nation hitherto had applied this knowledge with such thoroughness. The Japanese set a new standard for the Western world, simply by applying the facts that Western science had taught them.

XII

MODERN EXPLOSIVES

TO judge from the predictions and comments of the military experts, it would appear that the most surprising developments of the early weeks of the Great War in Europe in the autumn of 1914 were associated with the quick fall of the forts and fortified cities before the German siege guns.

The forts of Namur had been supposed to be almost impregnable; and the fortifications of Antwerp were by many military authorities regarded as beyond the reach of any destructive mechanisms that could be brought against them. At the very least, it was supposed that Antwerp would hold out for weeks or months against the invaders. Yet when the great siege guns were leveled against it, their missiles proved so utterly destructive that the capitulation of the devastated fortress was a matter of days—almost of hours.

It would appear that nothing as yet devised by human ingenuity in the way of defensive fortifications can withstand the terrific blasts of such explosives as the siege guns dropped upon the ramparts from their safe coign of vantage, miles away.

Of course, the precise range of the fortifica-

tions was known to the German gunners, and they could place their shells with unerring accuracy; whereas the range finders in the fortress were probably unable to locate the attacking batteries with any degree of accuracy before their weapons were put out of commission. In the matter of accurate placing of shots, the masked battery temporarily located in trench or ravine, or behind hill or building at a distance of many miles, had an infinite advantage.

It was reported that some of the German siege guns were of sixteen-inch (forty-two-centimeter) caliber—doubtless the largest field weapons ever carried in a campaign into an enemy's country. These monster weapons are of howitzer type—in effect, lengthened mortars. As compared with ordinary cannon, they are relatively short; but even so, their weight is enormous, their transportation being effected by powerful motors. The coming of the automobile had encouraged the development of good roads; and now automobiles were everywhere utilized for the transportation of troops and weapons and general supplies, making possible the maneuvering of large bodies of troops with a rapidity and facility hitherto without precedent.

When the invading hosts camped before a fortified place, therefore, they were not necessarily at a disadvantage as to power of armament. Their siege guns equaled or excelled in caliber and in range the guns of the forts themselves, so that even if the attacking batteries had been

susceptible of being readily located from the forts, they might still have carried on the duel on almost equal terms. For the earth mounds and walls and steel casements of the fortress afforded scant protection against the modern projectiles, once the range had been accurately gauged.

When a modern explosive is detonated it destroys whatever is in its vicinity, regardless of whether the structures be of earth, of concrete, of wood, or of steel.

The government chemists of all nations are constantly engaged in the endeavor to perfect new types of practical explosives. It would appear that the efforts of the German chemists have been at least as successful as those of any other company of experts; for the explosive shells that reduced the forts of Liège and Namur and Antwerp, the torpedoes that sank the *Aboukir* and *Hogue* and *Cressy* in rapid succession, and the mines that sank the *Audacious* performed their respective tasks in a way that left little to be desired from the standpoint of their designers.

If wet gun cotton and dynamite, as employed in the torpedoes and mines of the Russo-Japanese War, had seemed to lack something of complete effectiveness, no such criticism can be passed upon the new explosives that actuated the agents of destruction employed in the Great European War of 1914.

The precise composition and methods of manufacture of explosives employed by each govern-

ment are of course carefully guarded military secrets. It is reported, however, that the chief explosive used by the German military authorities in their shells, torpedoes, and sea mines is a compound known as trinitrotoluene, a compound of comparatively recent invention, which is usually referred to by British military experts as " T. N. T." and by Germans as " Trotyl."

It must not be supposed, however, that this new explosive is necesarily superior to the explosive used by other military powers at the present time, although it had advantages over the explosives in use only a few years ago. Nor must it be inferred that trotyl and the other new explosives are more powerful than any others hitherto known, as the layman might not unnaturally suppose.

In point of fact, there are substances known to the chemist that explode with greater violence than is manifested by any compound used in the construction of military explosives or propellants. The power of an explosive depends upon its capacity to produce a large volume of gas from a comparatively small amount of original solid matter. Judged by this standard, the most powerful explosive known is probably a salt of hydrazoic acid (N_3H), the ammonia compound of which (N_3NH_4) produces, according to the French chemist Berthelot, one thousand one hundred and forty-eight cubic centimeters of gases (at atmospheric pressure) for one gram weight of substance. No other known substance gives a corre-

sponding change of volume in passing from the solid to the gaseous state.

But these compounds of hydrazoic acid explode with extreme violence if heated to a temperature only slightly above the normal boiling point of water.

They are therefore far too sensitive to be used for the practical purpose to which military explosives are put. Moreover, their extreme violence of action would be to some extent a disadvantage. It would prevent their use as propellants, since they would burst the gun barrel; and if placed in torpedoes or mines they would shatter their inclosing cases almost to the condition of powder on being discharged, and on the whole would thus have a less destructive effect than would be produced by an explosive that burst the shell into relatively large pieces and, by relatively slow combustion, extended the area of its destructive influence.

Such tendency to overrapid explosion is a fault of picric acid and its derivatives, lyddite and melinite. And, in general, it may be said that the practical explosives now used in warfare are modified in such a way as to retard rather than to accelerate their rapidity of action when detonated.

Moreover, they are modified in different ways to meet different needs. For example, the British explosive, cordite, which is used for small arms and for cannon alike, is modified in action by the simple expedient of manufacturing it into

" cords "—whence its name—of smaller or larger size. The larger the cord, the slower its combustion. Thus it may be adapted to the requirements of a relatively slow-burning propellant or of a quickly detonating explosive—although for practical purposes another explosive, lyddite, is substituted in mines and torpedoes.

All this will perhaps be somewhat more clearly understood if we consider in detail the nature of explosions in general and the principles that govern the action of explosives.

HOW EXPLOSIVES ACT

An interesting elementary experiment may be made by scattering a pinch of lycopodium powder (which may be obtained at any drug store) in the air and striking a match. The almost invisible particles of powder—in reality they are pollen grains—will ignite with explosive suddenness, producing a miniature conflagration in the air that is distinctly startling.

The same phenomenon is manifested on a large scale when an explosion occurs in a coal mine. Such an explosion may result from coal dust floating in the air or lightly sprinkled about the corridors of a mine. The results are often highly disastrous.

The explanation of the phenomenon, with either coal dust or lycopodium powder, is merely that the combustible matter exists in the form of excessively minute particles surrounded on all sides

by air. If the same particles were brought together and compressed into a solid mass, relatively few of them would be in contact with the air, and when the mass is ignited combustion would take place slowly—as witness the slow burning of a lump of coal.

Now this difference between the rapid burning of the particles of coal dust when scattered through the air and the slow burning of the same particles when massed into a lump of coal is precisely the essential difference between explosion and ordinary combustion. In each case the chemical phenomenon involved is the union of the atoms of carbon, which are the chief constituents of coal, with the atoms of oxygen. In each case the result is the production of gases, chiefly carbon monoxid (CO) and carbon dioxid (CO_2). In each case the gases thus formed, obeying the nature of gases, expand with violence under influence of the heat that the chemical reaction generates.

And the only reason why we have in one case an "explosion" and in the other a simple "combustion" or burning is that in one case a large number of particles are burned simultaneously and hence a large quantity of gas produced too quickly to escape without damaging the chamber in which the burning takes place.

When coal is burned in a grate or stove, an air current constantly blows the combustion gases away and carries them up the chimney. If, however, the coal were burned, however slowly, in an

air-tight chamber, the walls of which were so constructed as to prevent the escape of heat, the gases formed would presently exert a pressure that would rupture the walls in a manner precisely equivalent to an explosion.

An all too familiar illustration of the difference between burning a combustible substance in the open and in a closed receptacle is furnished by the accidental explosion of gas ovens, resulting from turning on the gas too freely and igniting while the oven door is closed. But for that matter it is well known that even such an explosive as gunpowder may be safely enough burned in the open.

Yet the same quantity of powder if ignited in a closed chamber would produce a violent explosion.

The reason why the powder burns slowly in the open is that the heat produced is dissipated, so that the entire mass of powder is not rapidly raised to a high temperature. There is the closest association between high temperatures and the explosive activities of a gas, as will be explained more at length in a moment.

GUNPOWDER AND HIGH EXPLOSIVES

The essential principle on which the action of gunpowder and other manufactured explosives is based is simply that the compound shall contain within its own substance (1) one or more nitrogen atoms, and (2) enough oxygen to effect the

combustion of the other substances making up the compound.

Ordinary gunpowder, for example, which for some centuries was the only practical explosive known, consists of about seventy-five parts nitrate of potash, or saltpeter, intimately mixed (not chemically combined) with about fifteen parts of gunpowder charcoal and ten parts of powdered sulphur. Saltpeter is an unstable compound of potassium, nitrogen, and oxygen. Each molecule contains one atom of hydrogen, one of nitrogen, and three atoms of oxygen (KNO_3).

The presence of the nitrogen atom makes the molecule of saltpeter very unstable. For the nitrogen atom is essentially patrician. It seems to care for the society only of its own fellows. When forced into combinations with other atoms it has a strong innate propensity to liberate itself from the entangling alliance.

So the molecule of saltpeter may be thought of as a community that is always on the verge of disruption. Or it might be likened to a coiled spring held in place and ready to fly into action the moment the restraining force is released.

Notwithstanding the innate restlessness of its nitrogen component, the molecule of saltpeter, once formed, is powerless to change its condition unless the initiative comes in the form of some outside disturbance, so the gunpowder, of which it forms the chief part, is as inert and harmless as so much dirt, unless a disturbing influence is brought to bear on it. Suppose, however, that a

spark of fire comes in contact with the powder. The heat so increases the activities of the molecule as to enable its particles to break loose from their unwilling bonds.

In effect the spring is released.

Instantly the nitrogen atom dashes out in one direction, the oxygen atom in another. Heat is liberated, and contiguous molecules are similarly disturbed. Each nitrogen atom unites with a fellow atom to produce nitrogen gas. The oxygen atoms combine eagerly with the atoms of carbon supplied by the charcoal, producing carbonic acid gas and carbon monoxid. Some potassium atoms combine with oxygen; others are left to themselves. To supply their needs the sulphur was provided, for these two have an eager liking for each other.

So the mixture that was potassium nitrate (KNO_3) and carbon (C) and sulphur (S) has now become carbon monoxid (CO) and nitrogen gas (N_2) and carbonic acid gas (CO_2) and potassium sulphid (K_2S) and potassium oxid (K_2O) and potassium carbonate (K_2CO_3). The potassium salts, representing more than half the bulk of the original mass of the explosive, remain as an inert powder and are made visible in the form of smoke.

There are some complexities of the reaction that concern only the chemist. But the essential thing is that nearly half the substance of the powder has been converted into gases, which now, superheated in the process of transformation, press with terrific force in every direction in their

efforts to escape. Unless afforded instant exit (as by discharge of a bullet) they disrupt the walls that contain them, producing a more or less violent explosion.

The more modern types of explosives operate in precisely the same way, but owe their greater violence of action to the fact that they are made up of still more complex molecules, the entire substance of which is converted into gases. There being no inert metallic residue, such as that formed by potassium and sulphur, these "high" explosives are relatively smokeless.

The type substance which is the basic of all modern explosives is nitroglycerin, which is a very complex compound of carbon, hydrogen, nitrogen, and oxygen, the formula usually given being $C_3H_5N_3O_9$.

When this molecule is disrupted, nitrogen is set free as before, and the liberated oxygen atoms combine on one hand with carbon to form carbonic gas, and on the other with hydrogen to form water, which at the high temperature involved has the form of a truly gaseous vapor. The amount of heat liberated is relatively enormous, and there is no non-combustible residue.

Dynamite owes its explosive power entirely to nitroglycerin, which is incorporated with an absorbent form of earth. Gun cotton, made by treating cotton fiber or other vegetable tissues with nitric acid, is closely similar to nitroglycerin, which latter substance, as its name implies, is a product of glycerin. Picric acid, the foundation

of lyddite, is a coal-tar derivative of the same general formula as the other high explosives.

All these explosives depend on unstable nitrogen compounds that were built up originally through the action of living tissues.

Some conception of the energy stored in these unstable compounds may be gained from an estimate of the French chemist, Berthelot, according to whose tests the explosion of gunpowder may produce a pressure of twenty-four thousand atmospheres; that is to say, one hundred and sixty tons to the square inch.

THE POWER OF NUMBERS

Most readers are probably aware that the expansive property which characterizes gases, and upon which the effect of all explosives depends, is due to the activities of the molecules that make up the gas. The molecules are unthinkably but not immeasurably small. The number of molecules in a cubic millimeter (one-twenty-fifth of an inch) reaches a figure that requires for its expression a unit followed by sixteen ciphers—that is to say, that runs into quintillions.

Even the newly found "rare" gases of the atmosphere, of which only a "trace" is said to exist, are really represented by enormous numbers of molecules. There are, for example, about four hundred billion atoms of neon and about forty billion atoms of helium in each cubic millimeter of dry air at normal temperature. Yet

these numbers constitute such an infinitesimal company, as compared with the huge galaxies of nitrogen and oxygen atoms, that chemists have only recently detected their existence.

These figures give some faint conception of the minute size of the molecules, but in so doing serve to make the enormous energies exerted by these molecules the more mysterious. To explain the colossal power which the molecules are observed to exert, as when a bit of dynamite is exploded, it is necessary to recall that each and every molecule is an elastic body which is incessantly in motion, colliding with its fellows and bounding away as if possessed of an insatiate desire to find isolation.

It is estimated that each molecule collides with another molecule on the average of about six billion times per second.

Whoever cares to multiply that number by about forty quintillions (the number of molecules in a cubic millimeter) will set down in figures the number of collisions that take place each second in every millimeter of a gas at ordinary temperature.

The number, as will appear, is represented by two hundred and forty followed by thirty ciphers. In words, it is two hundred and forty millions of billions of billions; otherwise two hundred and forty *nonillions*.

This inconceivable number of times per second, then, the molecules collide with one another in each cubic millimeter of the air we breathe, or of

any other gas; and after collision spring back, like rubber balls, against any obstructing surface. Each individual push is infinitesimal beyond computations; but sundry billions of little pushes combined make an impulse that will burst barriers of steel. Reflect that the molecules become vastly more resilient and active with increased temperature, and the full action of the explosive is at least proximally explained.

Where else could one find a comparable object lesson in the overwhelming power of numbers?

MODERN SUBSTITUTES FOR GUNPOWDER

A practical gauge of the energy involved in the combustion of an explosive is furnished by the extraordinary temperatures produced. Thus a mixture of the metal aluminum granulated and oxid of iron, when ignited by a formulation powder, readjusts these atoms to form oxid of aluminum and pure iron, and does this with such fervor that a temperature of about three thousand degrees is reached.

This is a temperature far in excess of that which may be obtained with ordinary fuels in the blast furnace, the maximum of which is about one hundred and eighty degrees; although it does not quite equal the three thousand six hundred degrees Centigrade of the electric arc.

Even this temperature is exceeded, however, in the explosion of cordite in closed steel chambers. In the experiments of Sir Andrew Noble and Sir

S. Abel, in which cordite was thus exploded, it was estimated that the temperature approximated five thousand degrees Centigrade. At a far lower temperature than this iron is not only melted, but brought almost to the boiling point; the temperature attained by the exploding of cordite in a closed chamber must bring the metal almost to the point of vaporization.

Cordite, as already explained, is a form of smokeless powder used in the British army. It is composed of gun cotton, nitroglycerin, and mineral jelly.

Needless to say, it is not desirable to attain such temperatures in the use of cordite as a propellant. But the extreme heat produced is associated with the suddenness of the reaction; and it has already been explained that in practice this is controlled by the form in which the cordite is prepared. It obviously would not do to produce a temperature of five thousand degrees within a gun barrel, as the metal itself would thereby be liquefied or even vaporized; but by regulating the size of the filaments in which the cordite is made it is possible so to retard the combustion that heat production is regulated and adjusted to the needs of the particular weapon, the energy liberated being used to propel the bullet without material injury to the gun barrel.

What is true of cordite is equally true of other forms of smokeless powder, all of which have the same essential constitution; their peculiarity, as already explained, consisting merely in the fact

that their entire substance is susceptible of being transformed into the gaseous condition. One of the first problems that confronted the inventor when the idea of using high explosives of this character as propellants was conceived was to regulate the rate of explosion. A solution was found in the reduction of the explosive substance to a powder of varying degrees of granulation. Such an explosive as cordite burns from without inward, and its rapidity of combustion is determined by the size of the granules or particles. In this regard it does not differ essentially from coal, which, as we have seen, is explosive when reduced to a fine powder, yet burns slowly when in the form of nuggets.

When it is intended to use smokeless powder in heavy ordnance the substance may be prepared in cubes or blocks of different sizes, perforated with holes of varying size to regulate the surface exposure. In this way the same thing is accomplished that is accomplished with cordite when that substance is made in "cords" of varying sizes, from minute threadlike filaments to relatively large ropes.

Of course, when the explosive is to be used in a torpedo or mine, it may be desirable to utilize it in such mechanical form or in such chemical combination that it will operate far more suddenly than would be permissible when it is used as a propellant. But even here, as has already been pointed out, it is not always desirable to produce the most rapid explosion possible. In

the case of the shells used in land warfare, for example, it is better to have large fragments scattered widely, rather than to have a shower of minute splinters which operate within a small radius—better, that is to say, from the standpoint of the military tactician, whose essential purpose is, necessarily, the crippling or killing of as large a number as possible of the enemy's forces. And to produce this effect a comparatively slow explosion is more effective than an exceedingly rapid one.

Similarly, in case of a mine or torpedo, the explosive that acts with extreme rapidity may pulverize everything in the immediate vicinity, and in so doing needlessly exhaust energy that might more advantageously be utilized in the less complete but equally effective demolition of more distant objects.

It is obviously desirable that the explosives to be used in warfare as propellants, or in the construction of torpedoes or mines, should not be unduly sensitive to concussion. Everyone knows that ordinary powder may be rubbed or shaken or even struck with a hammer without danger of explosion. The higher explosives that have supplanted powder are, many of them, almost equally unresponsive. It is necessary, therefore, with the modern propellants, as with black powder, to use a so-called fulminate to detonate or explode the charge.

The first fulminates were discovered just at the close of the eighteenth century, and led very soon

to the invention of the percussion cap, the revolutionary effects of which have been detailed in an earlier chapter. The fulminate in question was discovered by Howard, and was a product of the action of alcohol on a solution of mercury in nitric acid. Other fulminates have since been made, but the fulminate of mercury retains its place as the most practical and effective of detonants.

This substance is a compound in which mercury is united with carbon, nitrogen, and oxygen. It is a white crystalline solid, very sensitive to friction or percussion. Curiously enough, its rate of burning is too high to allow it time to ignite common powder; so it is mixed with certain quantities of inert substances, such as glass powder, which reduce the rate of burning. There is a metallic residue when the fulminate is exploded, but this, of course, is of no consequence, as the amount of the substance used to detonate a charge of powder or other explosive is infinitesimal. A minute detonating spark suffices to start the essential conflagration in the powder chamber.

It will be evident from what has just been said that there is no essential difference between the metallic fulminates and other explosives, as regards their principle of action. The value of the fulminates hinges on the fact that they ignite at a low temperature, such as that produced by the concussion of a gun hammer or a similar impact.

THE EFFECTS OF HIGH EXPLOSIVES

In considering the effects of explosives it should always be recalled that an expanding gas presses equally in all directions.

The practical effect produced by an explosive depends, therefore, very largely upon the nature of the wall in which it is encased. Persons unfamiliar with physical laws often remark that dynamite exerts its force downward because it is observed to tear up the earth when exploded at the earth's surface. But, of course, this impression is altogether mistaken. Dynamite thus discharged, like any other explosive, presses equally in all directions, but the suddenness of the explosion causes it to tear up the earth at the same time that it is sending volumes of gases laterally and upward into the atmosphere.

When a mine explodes against the side of a ship its expanding gases press outward against the water quite as forcibly as against the hull of the vessel. But water is a practically incompressible fluid, far more unyielding than any mass of steel with which the ship's hull can be encased; so the effective expansion of the gas occurs largely in the direction of the vessel, shattering its hull.

When the explosive is ignited within a gun barrel it presses laterally and breechwise just as powerfully as it presses against the bullet. The only reason why the bullet goes forward while

the gun remains relatively stationary is that the bullet is smaller than the gun and less firmly anchored.

When the explosive projectile is detonated it of course operates on the same principle. If its shell is of uniform thickness throughout, its destructive effects will be manifest with equal force in every direction. The radius of its destructive action will be determined, as already explained, by the force of the charge itself and by the size of the fragments into which the shell is disrupted.

The changes in military tactics made necessary by the all-prevailing use of high explosives, both as propellants, to give great range to the projectile, and as disrupters of the projectile itself, when this is fired from ordnance (the use of explosive bullets in small arms being expressly prohibited by international agreement), has been more forcibly illustrated in the great contemporary European conflict than ever before. In advancing, the armies depart as widely as possible from the old " close formation "; they are forced to take advantage of every protective feature of the landscape to escape annihilation by machine guns and explosive shells; and whenever their progress is retarded, they at once begin digging elaborate systems of trenches on a scale never hitherto practiced in either ancient or modern warfare.

The short-handled spade used for this purpose was invented, it may be noted, by an American

engineer, Brigadier General H. W. Benham, of the Army of the Potomac, and was first used in our own Civil War. But its adoption, in one form or another, as a part of the regular equipment of the soldier is a matter of recent history. In the Great War in Europe the short, steel-bladed spade has played a part scarcely subordinate to that of machine gun and cannon.

Where the field is stubbornly contested, series of trenches are dug, each trench about four feet wide and five feet deep, the successive trenches being placed parallel to each other, and at right angles to the line of advance or retreat, at intervals of about a hundred yards, connection between them being effected by zigzag trenches, so that retreat or advance may be made under cover.

Wherever possible the trenches are themselves covered over in such a way as to shield their occupants from aërial bombs or the fragments of shells exploding overhead. In some cases concrete has been used to give further effectiveness to the barricades, so that the intrenchments partake of the character of permanent fortifications.

In digging the trenches care is taken to scatter the earth widely, so that there may be no conspicuous object visible from a distance to serve the enemy in range finding.

All this is a tribute to the effectiveness of the modern weapon, which has so changed the aspect of warfare that measures of protection that would once have been thought to savor of timidity or over-cautiousness are now matters of sheer ne-

cessity if the total annihilation of entire regiments or corps by machine guns and ordnance operating at long range is to be avoided.

The net result is that when the final count is taken it will probably appear that, despite the enormous destructiveness of modern weapons, the proportion of casualties has not been greater in this most recent of conflicts than in numerous antecedent wars of the old days of black powder, muzzle-loaders, and round bullets.

If so, it will appear that all the applications of scientific method to the art of warfare have not materially increased man's capacity to kill his fellow man.

Meantime, however, the application of science to the arts of peace has enabled the human populations to increase so enormously that the aggregate numbers of men engaged in the present conflict are unexampled, and the aggregate toll of human life will therefore be quite without precedent—totaling such numbers, indeed, as must make the most infuriated combats of ancient or medieval times seem bloodless by comparison.

A sad commentary, that, on the alleged progress of civilization!

French Death Mowing Machines

XIII

SUBMARINE AND AËRIAL WARFARE

ON the 22d of September, 1914, a British sea captain, sweeping the horizon casually from the bridge of his ship in the North Sea, noted that three war vessels were in view.

He observed that they were British vessels, and no doubt this gave him an added sense of safety; for his country was at war with Germany, and it would not have fared well with him had the warships that had thus come his way belonged to the enemy. But as it was all was well, and there was no occasion to observe the vessels more than casually.

A few minutes later the captain chanced to glance again in the direction of the warships, and was mildly surprised to observe that there appeared to be only two of them instead of the three that had first been noted. The observation was puzzling, but the captain appeared not to have been perturbed by it. When, however, after another interval of a few minutes, he again glanced in the direction of the warships, he observed that now only a single one was visible; and now the comprehension came home to him that something was wrong.

He gave orders to have his own vessel turn in the direction of the missing warships, and made all haste to approach the scene of the apparent disaster. But even as he approached, the third warship was seen to be in difficulty, and long before the merchantman could reach it this vessel also foundered without apparent cause, and disappeared.

All that the merchantman could do was to rescue a small number of sailors, the larger part of whose companions had perished when their ships went down, or in the chilly water soon after.

Meantime no enemy had been seen, and the cause of the disaster to the three ships could be only matter of conjecture. As to this, however, there was no reasonable doubt. The vessels, it appeared, had been successively torpedoed; and as they were in the open sea where no mines could be laid, the only explanation could be that a submarine vessel or fleet of such vessels had attacked the cruisers and wrought their destruction while themselves remaining invisible. Such had indeed been the fact, and it was subsequently revealed that the craft that had accomplished this extraordinary feat was a small submarine of the German navy, designated the U-9.

This insignificant vessel—so small that it bore merely letter and number, not being dignified with a name—had single-handed attacked three relatively formidable cruisers, and with a single torpedo for each sent them successively to the bottom, without itself receiving any injury what-

ever, and probably without being observed by any member of the crews of its quarry.

It is said to have been the same submarine that similarly attacked and destroyed the British cruiser *Hawke* a few weeks later, when the vessel was sailing alone in waters which, so far as was known, were quite free of the enemy's warships. The destruction of the *Hawke* was a very notable feat; but not to be compared, of course, with the unheralded attack on the three cruisers which resulted in the sinking of one after another—if the attack was really made, as is claimed, by a single submarine.

The names of the cruisers were the *Aboukir,* the *Hogue* and the *Cressy.* They were not warships of the newest and most formidable pattern, to be sure, but they were vessels of some significance, none the less; and there is no reason to suppose that their fate would have been different had they been warships of the most formidable size. For the modern torpedo, placed as were the torpedoes discharged by the U-9, constitutes a disrupting force that even the thickest plates of a dreadnought cannot withstand.

If there were any doubt as to that, the doubt was removed a few weeks later when the superdreadnought *Audacious* was destroyed off the coast of Ireland by a mine; for there is no essential difference (except as to size) between the submarine mine and the torpedo discharged by a submarine vessel, each carrying the same type of explosive. Indeed, it was not at first known

whether the *Audacious* had been destroyed by an anchored mine or by a torpedo discharged by a submarine.

A further demonstration of what the submarine boat can accomplish was given when, on the 12th of November, the British torpedo gunboat *Niger* was torpedoed and sunk by a submarine as it lay in the harbor at Deal. Here a German submarine had approached the British coast in the daytime and succeeded in passing through a mine field, presumably going under the mines, and had approached the pier at which the gunboat lay and discharged its projectile with telling effect, its presence having been quite unsuspected until its sinister purpose was effected.

Nor was the submarine itself seen even then. It was able, apparently, to make its way out of the harbor as it had entered, without encountering a mine and without being visible.

And in so doing it had accomplished an unprecedented feat, and necessitated the writing of a new chapter in naval history. It had shown what the submarine could do in the way of invading the harbor of an enemy, in defiance of mines and of the most elaborate equipment of coast defense, just as its companion craft, the U-9, had shown what might be accomplished, under favorable conditions, on the high seas.

A month later (December 13th) a British submarine, the B-11, performed an even more spectacular and daring feat by running under five rows of mines in the Dardanelles and sinking the

Turkish warship *Messudiah,* retiring in safety, although pursued by gun fire and torpedo boats. It had remained nine hours under water.

In the face of such achievements the most skeptical critic could no longer doubt that the submarine vessel is a war craft to be reckoned with in the naval contests of the future. Granted certain conditions, this little, frail, submersible shell might engage the most powerful battle ship on terms of something more than equality. An enemy that can approach unseen and can remain invisible even while making its attack, yet which carries a weapon capable of destroying the most powerful battle ship at a single blow, is one that must inspire respect not unmingled with fear. It supplies one of two uncalculable factors that make it impossible to predict the outcome of naval battles that otherwise might seem clearly predetermined.

The other uncertain factor referred to is, of course, the airship, about which we shall have more to say presently.

Meantime it should be observed that there is really nothing surprising about the successes of the submarines just outlined. The possibility of constructing submarine vessels that could blow up warships was demonstrated more than a century ago by Bushnell and by Robert Fulton. Submarine craft were used in the American Civil War, and in one case successfully, when the Federal ship *Housatonic* was torpedoed and sunk in Charleston Harbor on the night of February

17th, 1864. And in recent years the submarine has been so perfected as to become a reasonably safe and thoroughly manageable craft, the possible efficiency of which had been demonstrated again and again in nautical tests and sham battles.

It had been amply demonstrated that the present-day submarine is thoroughly seaworthy, and it was familiarly known that the periscope, through which light is reflected into the submarine, enabling its officers to see what is going on in the air above them, is so small as to be practically invisible from the deck of a ship under ordinary conditions of surface waves, even when so near that a torpedo might be discharged with almost unfailing aim.

And yet, thanks to the conservatism of the generality of mankind, it is probable that the demonstrations of the capacities of the submarine in actual warfare that were made in the early stages of the great European conflict in the fall of 1914 came as a surprise to most laymen, and to a very large number of naval experts as well. Notwithstanding the showing made by the submarine in times of peace, there is no doubt that skepticism regarding their actual capacities as war craft was quite general, and nothing short of the actual demonstration in war of their efficiency could dispel this skepticism.

But after one submarine had sunk four warships on the high seas, and another craft of the same type had entered a fortified harbor and sunk a war vessel at its pier, there remained little

opportunity for skepticism. The long-despised submarine had at last come to its own. The predictions of its advocates were verified.

A new chapter of naval history had been written, and again the question became pertinent as to whether the steel-clad leviathan, grown to such startling dimensions in the most recent decade, does not represent a type that must soon be superseded. At least it must be given additional protection—perhaps by the use of a second shell of armor a few feet inside the hull.

CAPACITIES AND LIMITATIONS OF THE SUBMARINE

Probably the greatest present defect of the submersible vessel is its relative lack of speed. It is obvious that in such a craft there is great need of conserving the supply of oxygen, and of course it is impossible to utilize large quantities of fuel without drawing correspondingly upon the atmosphere for oxygen. Also there results a corresponding vitiation of the atmosphere through the production of combustion. Moreover, space is at a premium, and both machinery and fuel must be kept at a relative minimum.

Most submarines hitherto, in recent years, have been propelled by gasoline engines when working at the surface, and by storage batteries when submerged. The crude early submarines were propelled by hand, but of course vessels of this type would be as much out of date in a modern navy as would rowboats at the surface. Attempts

have been made to utilize steam as the motive power, but this has obvious disadvantages.

It is reported that very recently the Dirsel engine has been used as the motive power for submarines, and it would seem as if this might be almost an ideal motor. It uses crude oil, which is introduced into the cylinder under high pressure and exploded there by the heat of compression, and it develops a high degree of efficiency. With the use of these engines it seems probable that the speed of the submarine, when operating at the surface, may be increased greatly beyond the present maximum of sixteen to eighteen knots per hour.

When the submarine operates at the surface a part of its power may be utilized to charge its storage batteries, which supply the motive power when the apparatus is submerged. Unfortunately storage batteries are very cumbersome and have relatively low power in proportion to their weight. Mr. Edison has done much to improve the storage battery in recent years, and it has been reported that he contemplates building a type of battery especially adapted to the submarine. Whatever the truth of this report, there can be no doubt that the development of an improved type of storage battery would greatly increase the efficiency of the submarine, by increasing its power, which is of course equivalent to increasing its speed.

If the submarine could be made to double its present maximum speed of eleven to twelve knots

per hour when submerged, its value as a fighting craft would be enormously enhanced, as it would then be able to overtake a battle ship under full headway in the open sea. At present it must approach its quarry by stealth, and a ship which keeps in motion may readily elude it.

Now that the submarine has thoroughly demonstrated its value, however, there can be little question that its limitations as to speed will be given a large measure of attention on the part of naval architects, and there would seem to be nothing inherent in the nature of the problem to prevent a development of submarines having speed equal to that of the fastest cruisers. At the moment the tendency is to make the submarine larger and larger; but it is quite possible that a solution of the problem may first be found by reducing the size, so that a type of very small submarine having great speed is developed.

For harbor defense a fleet of very small submarines having great speed might give almost absolute protection, it would seem, against the most powerful battle ships.

But of course there would remain the problem of submarine *versus* submarine. As yet there have been no battles in which one submarine was matched against another. But doubtless such encounters will occur in the not distant future, and this possibility must be taken into account. Heretofore the submarine has scarcely been considered as a defensive mechanism, but only as a craft calculated to take the offensive. As qualifying this,

however, it must be recalled that within recent years a good many submarines, notably those of the English navy, have been provided with small cannon, which can be elevated to the deck and used for defense against such small craft as torpedo destroyers when the vessel is operating at the surface.

The best defense of the submarine, however, is to place itself beyond the reach of the enemy by diving beneath the surface—a feat that requires only a few minutes.

Even when riding at the surface, the submarine of course offers a very small target. From its lookout tower the funnels of a hostile ship would be discovered long before the turtlelike back of the submarine itself was visible from the crow's-nest of the enemy; and four or five minutes later nothing but the periscope of the little vessel need remain above the surface—not even that, indeed, should the navigator decide to take a yet deeper dive.

Under such circumstances it would seem as if a submarine might readily enough make its escape even surrounded by an entire fleet of surface vessels, perhaps pausing to cripple or destroy two or three of its pursuers with a torpedo for each as, itself quite invisible, it passed through the line.

AERIAL SCOUTING

Should a sharp-eyed lookout discover the periscope of the little vessel, however, it is obvious that the peril of the submarine might be very great. A well-placed shell or two from a battle ship, exploded in the water just above it, would work its destruction. Or it might be rammed by a torpedo boat or a torpedo boat destroyer. And against such attacks its only refuge would be to settle rapidly to a greater depth. The submarine that torpedoed the British cruiser *Pathfinder* is said to have been fatally rammed by the doomed vessel before the latter experienced the full effect of the injury that sent it also to the bottom soon after it had thus retaliated on its enemy.

Again, the French cruiser *Waldeck Rousseau,* on November 19th, 1914, when attacked by aëroplane, destroyer, and submarine, rammed the latter effectively, and itself remained uninjured.

But experience has shown that it is extremely difficult to discover the periscope of the submarine from the bridge or lookout stations of a battle ship, even when it is known that the submerged boats are in the neighborhood. So the danger from this source is slight.

It has been found, on the other hand, that an observer in an airship, looking directly down upon the water, can often see objects at a considerable depth. So it would appear that the submarine's chief danger is from aërial craft. It is rather curious that these two newest types of

fighting mechanisms should thus be pitted against each other.

To attack from such a source the submarine obviously has no response; so there would seem to be no reason why the dirigible balloon or aëroplane might not fly directly over the submerged vessel, once it is discovered, and drop explosives into the water just above it with destructive effect.

The air craft which may thus be expected in a measure to checkmate the submarine constitute so recent and so spectacular an addition to the fighting equipment of our navies and armies that the history of their introduction is familiar, at least in general terms, to everyone.

It will be recalled that M. Santos-Dumont made his spectacular flight about the Eiffel Tower at Paris, which first clearly demonstrated the possibilities of controlling the direction of flight of a balloon, in the year 1901. Almost simultaneously the first successful flights of Count Zeppelin's airships began to be made.

Two years later, in December, 1903, the first flight in a heavier-than-air machine was made by the Wright brothers at Kittyhawk, North Carolina.

Several years elapsed, however, after the first partially successful trials of the dirigible balloons, before these mechanisms were developed to a stage at which they assumed even relative usefulness. And the aëroplane of the Wright brothers remained quite unknown to the general public

for more than four years after its practicability was demonstrated, during which time the inventors vainly strove to interest the military authorities of their own government, and were only partially successful in attracting the attention of foreign governments, to which they turned after Washington had persistently refused to give their wonderful new war machine a trial.

So the extraordinary and unprecedented development of the dirigible air craft, which has resulted in giving fleets of these vessels to every important military power, has taken place within a very brief term of years.

He would have been regarded as a visionary and foolhardy prophet who had predicted at the beginning of the nineteenth century that in the next great European war flying machines would play a conspicuous part, modifying almost to the point of revolution the tactics of attack and defense. Yet such has proved to be the case.

By the time when the great conflict broke out in Europe in the late summer of 1914 each of the chief participants in that conflict was provided with a notable array of dirigible balloons and aëroplanes; and the latter type of craft in particular had already demonstrated their value as accessories to the military organization in a number of minor conflicts, notably in the Balkan wars and in Mexico. From the outset, then, companies of airmen were requisitioned at the front, and their scouting capacities gave the tacticians such sweeping vision as has never hitherto been pos-

sible, and made it out of the question to hope to move considerable bodies of troops into any territory within a hundred miles or so of the enemy without his full knowledge.

Not only could the airmen discover the movements of the enemy, and thus frustrate any attempts at surprise, but on occasion they gave additional service by dropping smoke-producing bombs directly above the enemy's intrenchments, thus supplying a visible object which could be sighted by the range finders of their own army.

The airmen performed a service of another kind by flying far into the country of the enemy, and terrorizing the inhabitants by dropping bombs here and there. In the course of these raids, successful attempts were made to drop bombs on the hangars in which balloons of the enemy were housed, and it would appear that various dirigibles were thus put out of commission. A notable instance of this was the flight of three English aëronauts on November 22d, 1914, from French territory to the headquarters of the Zeppelins at Friedrichshafen. After dropping bombs, two of the airmen returned safely, the third being brought down, wounded, by the rifle fire of the defenders.

Meantime dirigible balloons had made night forays into the territory of the enemy, dropping bombs with destructive effect, in particular upon the buildings of Antwerp.

But in general it may be said that the early history of the air craft in the great conflict which

first gave opportunity to test their capacities revealed them as scouting mechanisms, rather than as mechanisms of offensive warfare. The quantity of explosives that an aëroplane could carry is at best limited, and the accuracy with which these can be discharged from a height is not very great. The dirigible balloon could of course carry a far larger supply of explosives, which could perhaps be discharged with greater accuracy, inasmuch as the machine might be headed into the wind and held practically stationary; but the extreme vulnerability of the dirigible greatly restricts its possibilities in this direction.

Not only is the dirigible in great danger of destruction by missiles dscharged from the earth by guns especially constructed for that purpose, but it must, under ordinary circumstances, be quite at the mercy of any aëroplane that can rise above it and sweep over it, carrying a bomb suspended from a thin cable.

It is by no means certain, however, that a fleet of dirigibles invading the enemy's territory unexpectedly at night might not attack a fortified position or a fleet of ships with very destructive effect. The possibility of such an attack is one that the military and naval authorities must bear constantly in mind. The order restricting the lighting of London to the minimum requirements, that the location of the city might be difficult to discover from the point of view of an airship, gives tangible illustration of the recognition of this danger.

It must be understood, also, that the offensive equipment of the airship is by no means confined to bombs to be dropped or thrown by hand. A special armament of guns has also been provided for the great dirigibles, notwithstanding the danger that must accompany the use of explosives in the vicinity of their gaseous envelopes.

To minimize this danger it is said that the newest Zeppelins are provided with cagelike receptacles to be suspended five hundred meters below the body of the balloon by a thin cable. The cage is designed to have a single occupant, who will manipulate the gigantic bombs or torpedoes carried thus at a safe distance from the inflammable gas of the balloon.

In the attempt to guard against the attacks of aëroplanes, the Zeppelins are said to have machine guns mounted on top of the gas bag, their operator being in telephonic communication with the navigator in the car under the balloon. Machine guns of special construction are also carried in the main car itself.

Meantime it is said that Sir Hiram Maxim and others have invented bullets that will set fire to the hydrogen, thus destroying the airship, if they penetrate its envelope. To meet this danger, the airships are shielded as far as practicable with metal plates; but of course the weight makes the use of anything like an effective armor plating impossible.

On the other hand, the small body of the aëroplane may be plated with metal of sufficient thick-

Armored Aëroplane with Machine Gun

ness to give a good degree of protection to its occupant against rifle balls fired from below or from either side. And although the wings of the aëroplane cannot thus be protected, this is a matter of no great consequence, as ordinary bullets may penetrate them in almost indefinite numbers without doing material injury.

The offensive equipment of the aëroplane includes ordinary bombs, to be dropped by hand or through a tube designed to give them direction; bombs with hooks designed to be carried at the end of a cable and swung against the side of a balloon; and sheafs of arrows a few inches in length and weighing about an ounce each. The latter are said to be carried and discharged in packets of one thousand by the French airmen. When discharged from an altitude of two or three thousand feet, they attain enormous velocity, their momentum being sufficient to carry them clear through the body of a horse and rider. No doubt these missiles have proved effective on occasion when launched against bodies of men marching or lined up in the trenches; and it was reported in December, 1914, that a German, General Von Meyer, was struck by one of these missiles and instantly killed when descending from his automobile in Belgium.

Guns have also been especially designed for use in the aëroplane. An interesting example of this type of weapon is a rapid-firing gun invented by an American officer, which is provided with a corrugated aluminum jacket, to minimize heating by

facilitating radiation; and which, as has been demonstrated, can be used effectively from the vantage ground of an aëroplane in full flight. In aëroplanes of the monoplane type the machine gun is mounted above the body of the machine, in front of the pilot. In the biplane the operator of the gun may sit beside the pilot, or in a seat especially designed for his use under the seat of the pilot, beneath the lower plane. The latter arrangement, as adopted in some English biplanes, seems to give the pivoted machine gun peculiar advantages in directing its missiles against troops of soldiers on the ground or against the deck of a ship.

The chief use of such a weapon, however, will be in offensive or defensive conflict with another airman, rather than in attacks directed against forces at the surface of land or water. Nothing hitherto developed suggests that the flying corps are likely to have real significance in competition with the infantry and artillery services or the regular naval equipment of the modern military machine, although their place as invaluable auxiliaries is incontestably established.

It does seem within the possibilities, however, that a modified type of aëroplane may come to perform the function of an aërial torpedo; and if this prediction should be verified, our navies will be supplied with a new weapon of quite unexampled destructiveness.

Justification for the prediction is found in the success that has attended recent efforts to sta-

bilize the aëroplane by means of gyroscopic apparatus. The efforts of Mr. Elmer E. Sperry, in particular, have been notably successful. He had developed a gyroscopic mechanism that stabilizes the aëroplane both laterally and longitudinally, adjusting it so to meet the shifting currents that the pilot is enabled to navigate it for almost an indefinite period without touching the levers. Mr. Sperry made a spectacular demonstration of the powers of his gyroscopic stablizer for the military authorities of France in the spring of 1914, receiving a large monetary prize as evidence of his success in the contest.

Another interesting demonstration was made in January, 1915, when Mr. Sperry's son piloted a gyro-stabilized aëroplane from the Brooklyn Navy Yard to West Point and return, passing alternately over and under the East River bridges, and seeming to ignore the treacherous air currents that make such a trip exceptionally hazardous.

Mr. Sperry's gyroscopes are not powerful affairs capable of counteracting the force of air currents directly, after the manner of the Schlick gyroscope in controlling the motion of ships at sea. On the contrary, they are small and relatively feeble mechanisms, which exert their influence solely on the warping device (or its equivalent) of the wings of the aëroplane to promote the lateral stability, and on the horizontal rudders to give longitudinal stability. By their automatic action, they control the warping device and the horizontal rudder so effectively as to give the

aëroplane stability even in the midst of the most shifting and vacillating of air currents. Once they are set in motion, they operate quite independently of human control, and there is apparently no reason why they should not stabilize, within certain limits, an aëroplane that had no pilot.

Should experiment prove this to be possible, there would appear to be no reason why Mr. Hammond's device for radio-control, which has proved so effective in the case of his radio-controlled ship and torpedo, should not be applied to the aëroplane as well. It would be necessary, of course, to control horizontal as well as vertical rudders, thus complicating the problem slightly, but seemingly introducing no new principle.

Mr. Hammond directs his radio-ship in any desired course. He sends it out to sea eight miles—as far as it can be well observed with the telescope—and causes it to turn about and come back to its dock directly or in any zigzag course that may be suggested.

He could cause it to drive straight at a target, say another ship; and if, through some error of the operator, it missed its mark, it could be made to turn about and pursue the object, running it down with a certainty conditioned only on its relative speed and the accuracy of vision of the director on shore who controlled the electrical waves that actuate its steering mechanism.

Suppose now that this device for radio-control were applied to an aëroplane stabilized with gyroscopes and sent into the air without a human pilot,

but carrying a ton or two of dynamite or other high explosive in lieu of passengers. There is no obvious reason why such an air craft might not be caused to navigate the air and to descend, at will of the distant operator, upon the deck of a warship or upon a fortification with unerring accuracy and with appalling destructiveness.

The advantage of such a projectile over a submarine torpedo would be its far wider range of action, owing to its visibility, its greatly enhanced speed, and the annihilative momentum it would acquire when launched from a height; coupled with the fact that it would normally descend on the relatively unprotected decks of the ship instead of meeting the resistance of heavy armor plate.

Of course the aëroplane torpedo would be visible to the enemy as well as to its directors, but it could be made to take a zigzag course that would make it an exceedingly difficult target to hit; the probability of getting its range at a distance would be almost negligible, and even though it were riddled with bullets as it neared the mark, the effectiveness of its impact would not be lessened.

All this, of course, is theoretical. As yet there is no record of the launching of a passengerless, let alone a radio-controlled aëroplane. But that such attempts will be made in the near future cannot well be doubted; and it requires no great use of the imagination to conceive, that should these attempts be met with such success as seems probable, the radio-controlled aëroplane may have an

important share, in conjunction with the submarine, the radio-controlled boat and torpedo, and the man-controlled airship, in completing the transformation of military methods. The warfare of to-day is something very different from the warfare of half a century ago; the warfare of to-morrow will doubtless show still more startling developments and transformations. The precise nature of these transformations can of course be only conjectural; yet at least their general character would seem to be adumbrated in the scientific developments of our own time.

And, however much we may deprecate the fact, it would appear that all signs seem to indicate that the application of scientific knowledge in the development of mechanisms of warfare is likely to make war not impossible, as visionaries have dreamed, but merely more destructive. The warless age, if it ever comes, will be the fruitage of a civilization some hundreds of generations subsequent to our own.

THE END

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